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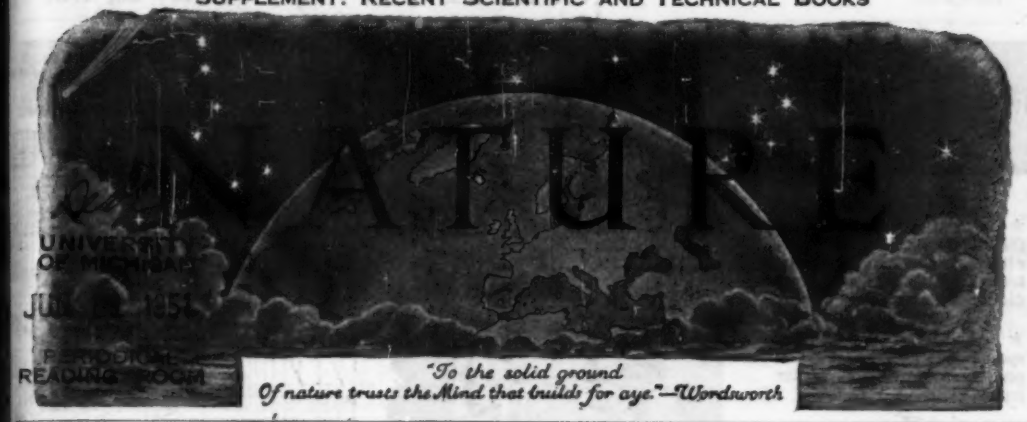

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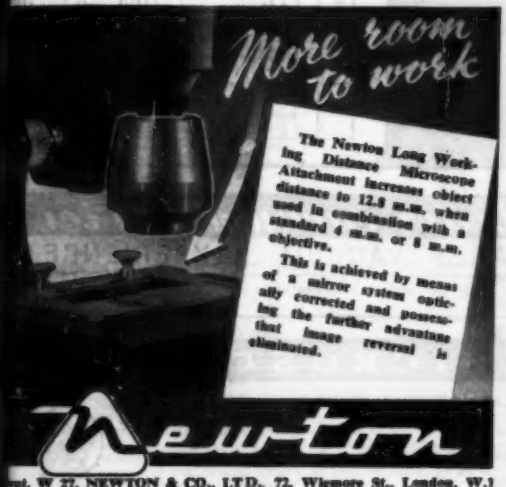
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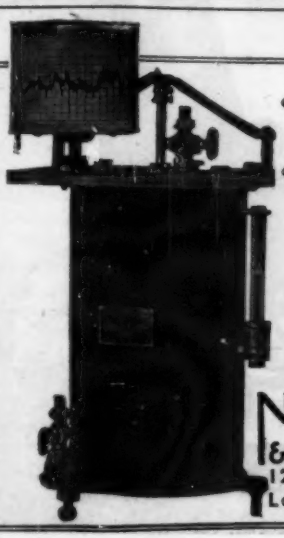

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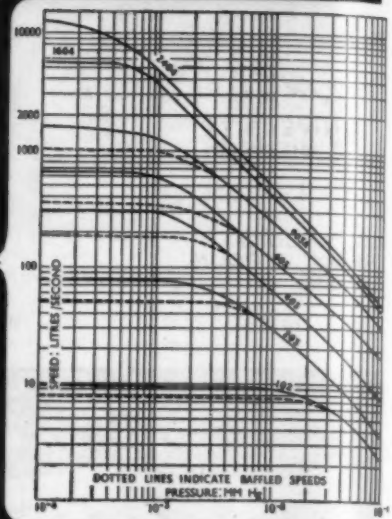

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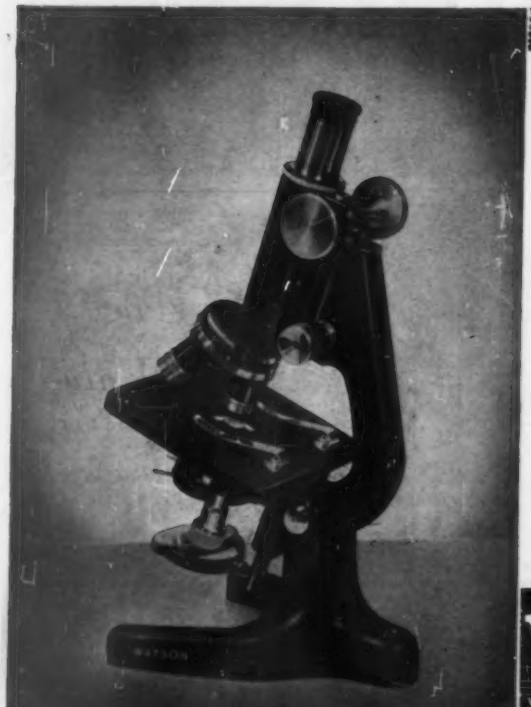

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NATURE

No. 4256 SATURDAY, MAY 26, 1951 Vol. 167

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TECHNICAL AND TECHNOLOGICAL EDUCATION

IN view of the extent to which the Massachusetts Institute of Technology has figured in current discussions on higher technological education, the report of the Committee on Educational Survey to the Faculty of that Institute is of special interest. The report has recently been summarized in *Nature* (167, 470; 1951); there are several features in it, however, which bear particularly on some aspects of higher technological education in Great Britain, and they can be usefully examined further. The main report is supported, for example, by the report of a Committee on Staff Environment. The former had recognized that the most effective teaching requires an environment which is stimulating and conducive to creative work on the part of the staff, and that the performance of an institution is determined ultimately by the quality of its staff; the latter examines what is required more specifically for the Massachusetts Institute of Technology.

Much that is recommended in this latter report appears in general terms in the Barlow Report on Scientific Staff published in 1945; but the significance of the present report in relation to technological education in general is the strong support it lends to those who insist that the administrative side of the technical colleges in Great Britain precludes their development into the type of institution which can most effectively serve the needs of higher technological education. The evidence of this report on this point is the more impressive because it is so independent of any possible bias as regards British institutions.

Other features of the main report which bear particularly on the current discussion in Great Britain are the discussion of sponsored research and its effects, and the emphasis which the Committee places on the integration of professional and general education. It considers that the education programme or policy of the Massachusetts Institute of Technology has at times been unduly vocational, and it is convinced that an appropriate balance is possible between a training in science and technology and a sound general education at the undergraduate level. In fact, it believes that the general and the professional objectives should not be separated, and that in a four-year programme they can be combined to produce educated men with a sound basis for a professional career.

This belief that sound judgment and creative imagination can be developed through the proper kind of study of professional problems in a professional atmosphere is clearly akin to the school of thought in Great Britain of which Mr. Eric James is so able an expositor. The insistence that the tendency to increase the extent of individual subjects should be resisted is also to be noted, and the observations on the need for undergraduates to have sufficient time for reflective thinking. If these conclusions are sound, they point strongly to the appropriateness of developing technological education

within the universities, rather than in separate institutions. These views are, indeed, a return to the early ideals of the founder of the Institute, W. Barton Rogers; but there is another comment of that period quoted in the report which is worth considering to-day. C. W. Eliot was maintaining in 1869 that a technological school is best placed in a great industrial centre, where the professors of science have the opportunity of daily contact with practical affairs and of watching the day-to-day development of inventions. If there is any substance for such a belief, the place for the expansion of technological education is in the appropriate departments of such universities.

Some support is lent to this idea by the success which has attended the Institute of Paper Chemistry at Appleton, Wisconsin, the success of which has been attributed in part to its location in a compact area of diverse paper manufactures and paper-mill machinery manufacture unequalled elsewhere in the United States. Here, however, so far as Great Britain is concerned, regard should be had to the research associations, the functions of which in supplying industry with trained men and women call for consideration also in the planning of technological education. A free interchange or movement of staff between the research associations and industry and the universities is desirable from every point of view. It may well be that the educational functions of the research associations will become of increasing importance, and that their participation in technological education, especially at the postgraduate level, might help to solve some of the difficulties in regard to equipment which hinder its expansion at the universities.

The position of the research associations bears also on the question of sponsored research. The Committee of the Massachusetts Institute of Technology fully recognizes the advantages to the Institute of a sponsored research programme, provided that staff and resources are not over-committed. Against the advantages of closer contact of graduate students with real engineering problems, of the provision of special facilities that contribute to the advance of engineering knowledge, and of the support of fundamental scientific investigations which might otherwise be too costly to undertake, certain dangers have to be considered. Not only may the technical staff of the Institute be occupied excessively with administrative activities, or attention diverted unduly from fundamental scientific inquiry; there is also risk of competition with industry, and of placing an excessive proportion of the Institute's finance on a short-term basis. Moreover, the Committee regards the conduct at an educational institution of any research or development work that comes under secrecy regulations as undesirable. These conclusions are largely those that have been reached independently in Great Britain as regards sponsored research at the universities.

The recommendations that follow for efforts to increase the support of fundamental scientific inquiry, to broaden the basis of sponsored projects by increasing the industrial participation and continuing to refuse sponsored research primarily for profit or as a contribution towards salaries, are essentially designed to favour the maintenance of a balance between sponsored research and other activities, which will ensure that the Institute can adjust its policy more readily and independently to changes.

This aspect is, however, scarcely considered in articles on British universities and research which appeared in the February issue of the *Universities Quarterly*, although one of them discussed technological research in the industries and another scientific research in the universities from the development angle. In the first of these two articles, Dr. N. J. Petch, after emphasizing the value of the work already done in the universities, stated that, from the point of view of technological research, expansion of the existing departments of technology is likely to yield a greater return on expenditure than the establishment of a new technological university, since in institutions of university type only a small proportion of the annual expenditure could go towards the actual cost of equipment. The costliness of equipment for technological research is, of course, a prime difficulty in the expansion of technological education, and is one reason why some central planning of resources is unavoidable. Even if the reinforcement of existing institutions and departments is more economical than the development of new ones, some selection is essential in order to avoid dispersal of effort and consequent inefficient use of expensive installations.

To this end the co-operation of industry and of the research associations may, as already noted, also be important; but responsibility for higher technological education and of university education by some one body of the type of the University Grants Committee is a first condition, and the very fair appraisal of the functions of the National Research Development Corporation which its technical manager, Mr. M. Zvegintov, contributes to this symposium confirms this impression. There is clearly no thought of encouraging sponsored research, but it is at least possible that as the work of the Corporation extends and becomes better known, it may be able to make some contribution to technological education and research through its pilot-plant facilities. It is a possibility that should be kept in mind, though it has evidently eluded both the Parliamentary Secretary to the Ministry of Education, as indicated in his reply on the debate on higher technological education on March 22, and also the Association of Technical Institutions and the Association of Principals of Technical Institutions in the "Statement of Policy on the Future Development of Higher Technological Education" which they prepared recently*.

The debate initiated in the House of Commons by Mr. Ralph Morley on March 22 did not provide quite the same condemnation of the recent report of the National Advisory Council of Education for Industry

* Statement of Policy on the Future Development of Higher Technological Education. Pp. 15. Prepared by a Joint Committee of the Association of Technical Institutions (Hon. Secretary, Polytechnic, Regent Street, London, W.1); Association of Principals of Technical Institutions (Hon. Secretary, Technical College, Dudley).

and Commerce as did the earlier debate in the House of Lords. Mr. H. N. Linstead, however, was severe enough in his strictures and urged the Minister to refer the report back to the Council with the comment that its recommendations do no more than touch unrealistically the fringe of the problem, and that it should now turn its attention to the problem of producing the right institutions in which the technologists of the future are to be trained. Virtually the only supporter of the report was the Parliamentary Secretary to the Ministry, the other four speakers all showing a clear grasp of the difference between the technologist and the technician, even if they were unable to define the distinction, and an appreciation of the problems involved for both universities and technical colleges.

To some extent Mr. Hardman appeared to appreciate the issues also; but although he rightly referred to the importance of building on existing traditions, he showed no real appreciation of the importance of the staff factor, and the trend of his remarks about expansion of technological training in both universities and technical colleges is not reassuring. It suggests that there is real danger that, on one hand, the Ministry may disperse resources too widely—over technical colleges generally—to make any effective contribution to higher technological education, while at the same time the training of technicians may be seriously hindered. Uneasiness on this score will be increased by the entirely misleading impression he gave of the amount of support which the Advisory Council's report has in fact received from responsible and disinterested opinion.

It is all the more surprising to find that the Association of Technical Institutions and the Association of Principals of Technical Institutions accept the main recommendations of the Advisory Council's report, because their own Statement of Policy directs attention to some of the main weaknesses in the present position. It is pointed out, for example, that the most serious problem associated with the development of higher technological education is that of staffing. The recent awards have now freed local authorities from the restrictions imposed by the Burnham scales of salary, and they are now able to offer more attractive conditions if so disposed. Whether they will do so without some change in the government of the technical colleges is clearly doubtful to the two Associations; but neither of the changes which the Statement of Policy suggests here is likely to contribute towards the atmosphere of freedom and independence which is as important as actual salary scales in attracting the right type of staff.

The Statement of Policy shows a greater awareness of the needs of the technician than some other contributions to current discussion of the future of technological education; but the question of balance is ignored, and one might well have looked for some more authoritative guidance on the difficult question as to whether higher technological education and technical education can really be conducted with efficiency in the same institution. The Statement, indeed, illustrates the need for some independent body which will put the right questions to both university and technical college, and which is competent to allocate resources from a national point of view and uninfluenced by questions of local politics or professional rivalry. On some of the questions, it would appear that a more searching analysis of the actual facts is still required before a wise decision as to policy can be made.

"DOFLEIN'S PROTOZOA"

Lehrbuch der Protozoenkunde

Eine Darstellung der Naturgeschichte der Protozoen mit besonderer Berücksichtigung der parasitischen und pathogenen Formen. Begründet von Franz Doflein, fortgesetzt von Prof. Dr. Eduard Reichenow. Sechste Auflage. Teil 1: Allgemeine Naturgeschichte der Protozoen. Pp. iv+408. (Jena: Gustav Fischer, 1949.) 21 D. marks.

THIS sixth edition of Doflein's classic work, now being edited by Prof. E. Reichenow, is published twenty years after the fifth edition, which Prof. Reichenow also edited and extensively revised. Throughout all its editions, this book has been a fine example of the high standards of the house of Gustav Fischer, of Jena, which publishes it; and the fine printing and beautiful illustrations of the fifth edition will still entitle it to a place on the shelves of those who value a scientific book for the quality of its production as well as for its contents. For, although the printing of this sixth edition is no less skilful, it has been handicapped by the quality of the paper used. The type is still clear and the illustrations still have their characteristic distinction and scientific value; but much of the æsthetic quality of the earlier editions has inevitably been lost.

In other respects the book retains the authority communicated by Doflein to its first edition. The plan of the first part of it is not changed, but careful revision is evident throughout. Much of the text remains as it was; but many paragraphs have been rewritten, space has been saved by the use of small type for sections considered by the editor to be less important than others, and many interpolations help to bring the book up to date. The illustrations, too, have been revised. Some of the figures printed in the fifth edition have been omitted and new ones have been inserted. Although there are nineteen fewer figures, the wealth of unexcelled illustration which has always been a feature of "Doflein" is retained to delight and instruct the reader.

Criticisms of some of the views expressed will probably be made. No one can write, or even edit, a book like this, which records and seeks to interpret so much detail and discusses so many fundamental problems, without initiating argument and controversy. It is, indeed, remarkable that one man can still be found who has the ability and breadth of experience to compass so wide a field and to deal with so much variety of research. It is an accomplishment that is inevitably becoming rare. In Great Britain, where the protozoologist who studies more than the economic aspects of protozoology has never received sufficient encouragement, it has not been publicly recognized since King's College, London, enabled Minchin to found a tradition which has been unhappily allowed to die. But "Doflein"—or, as it

now is, "Doflein–Reichenow"—remains to exhibit to us the Protozoa, not only as causes of serious diseases of man and animals, but also as organisms of which the astonishing beauty and variety of form, physiology and adaptation pose for us unsolved problems of great biological importance. It is a pity that a work like this, to which there is nothing comparable in other languages, has never been translated for the English-speaking reader.

G. Lapage

SOUTH AFRICAN ALOES

The Aloes of South Africa

By Gilbert Westacott Reynolds. Pp. xxiv+520+77 plates. (Johannesburg: Trustees of the Aloes Book Fund, 1950.) 73*s.* 6*d.*

THIS sumptuous volume concerning a fascinating genus of succulents is the result of the labour of one who, to quote from the foreword written by the late General Smuts, "has explored almost every hole and corner of South Africa where Aloes grow". The author's indefatigable search for members of this genus has ensured a knowledge of the natural habitats of these plants and a familiarity with them in all their variations under their native environments that have produced a monograph of unrivalled reality.

Moreover, the author's skill as a photographer both in colour and in black-and-white has resulted in a series of photographs of the species in their wild setting that will be the envy of those writing monographs on other genera.

A group of this character can only be effectively studied by extensive field-work, and we have in this book the outcome of the effective combination of the results of the study of the growing plants with examination of herbarium material. It is interesting in this connexion to note the author's comment: "The more field experience and the nearer to Nature and instructive perception one can approach the more is one urged along the path of grouping within reason, rather than splitting"; or again, "some present day European workers have added to the confusion by erecting species and varieties on the flimsiest pretext with total disregard as to the manner in which Aloes grow and vary in their South African natural habitats".

The first part of the work is concerned with a brief account of the early travels in South Africa, but it was not apparently until 1674 that specific mention of these plants was made. Later, in 1685–86, Claudius, who accompanied the expedition of Simon Van der Stel, painted four species of aloe. Also, there is good reason for believing that at the end of the seventeenth century Oldenande had ten species of the genus in cultivation in the Gardens of the Dutch East India Company, but in general the earlier collections paid little attention to the aloes. Historical notes are provided regarding a number of botanists that have contributed to the study of the genus, and of these some of the more notable in recent years have been Dr. S. Schonland (1860–1940), A. Berger, Dr. Pole Evans, N. S. Pillans, Dr. F. Z. Van der Merwe, and last of all the author, Mr. G. W. Reynolds himself, who, though not a professional botanist, has described no less than twenty-five new species besides several distinctive varieties.

These historical notes, together with a short description of Bushman's paintings of two aloes, occupy the first seventy pages. Bibliographical notes in the pre-Linnæan and later period are next considered (pp. 71–96), and these together with brief accounts of taxonomy, a list of references and a table of flowering periods constitute the first part.

The second part (pp. 103–505) is devoted to the descriptions of the species themselves and their main varieties, all of which are illustrated in their native habitats either in black-and-white or colour, sometimes in both, and the individual flowers are shown natural size in various stages of development. The colour plates illustrate no less than seventy-five species, three varieties and three hybrids.

For every species the author provides bibliographical references, a detailed taxonomic description, an account of the type, locality and distribution, flowering period, and notes on variation and putative hybrids that throughout witness to a profound knowledge of the living plants. One cannot, however, but regret the absence of distribution maps as a record of the author's unrivalled field experience which words alone cannot convey.

The South African species here described number no less than one hundred and thirty-two, of which more than eighty are to be found in the Transvaal area. Of the ten sections of the genus, two only have no South African representatives. These are the section *Aloinella*, to which the dwarf Madagascan *A. haworthioides* belongs, and *Sabæaloe*, of which the Arabian tree aloe, *A. sabæ*, is the type. The aloes range in height from dwarf species such as *Aloe albida* from the East Transvaal and *A. saundersiæ* from Natal, both only about 15 cm. in height, to large trees such as *A. bainesii* that can attain 18 m. The very distinctive *A. polyphylla*, with its beautiful dense, almost spherical, rosettes of leaves like a glorified house-leek, one of the rarest species, is confined to a small area in Basutoland, while *A. striata* with its coral-red flowers is equally noteworthy for the beauty of its inflorescence. An unusual habit is represented by the scrambling *A. ciliaris*, as also by *A. suffulata* with a very slender inflorescence that obtains support from the bushes through which it scrambles, while *A. mitriformis* has shoots that are prostrate extended rosettes.

A more-or-less bulbous habit is exhibited by *A. kniphofioides* and the Rhodesian *A. bulbicaulis*. Naturally, one thinks of such succulent plants in relation to dry habitats, and some of the aloes are extremely resistant to drought. For example, *A. krapokliana* grows in areas with an annual rainfall of less than 10 in., while the procumbent *A. claviflora*, with its curiously oblique red inflorescences and 'fairy-ring' like growth, occurs in areas with a precipitation of less than 5 in., and Mr. Reynolds mentions this species as frequently having to endure temperatures of more than 100° F. But, at the other extreme, *A. nubigena*, which is found on the precipitous faces of the Drakensburg at an altitude of about 4,700 ft., enjoys an annual rainfall of 75 in. and grows in damp shaded situations within the clouds and the spray zone of a waterfall.

The genus thus lacks neither morphological variety nor ecological interest, and this account is a monument to the assiduous labours of the author, who travelled more than a hundred thousand miles in search of his data and has provided in this book a beautifully illustrated record that will remain a classic monograph alike in its contents and presentation.

E. J. Salisbury

HEBRIDEAN LAMENT FOR A CHANGING WORLD

Afoot in the Hebrides

By Seton Gordon. Pp. 322 (65 plates). (London: *Country Life*, Ltd., 1950.) 30*s*. net.

SETON GORDON is by far the best known of writers on natural history, landscape and folk-lore of the Scottish Highlands and Islands, and his fund of knowledge of this paradoxical corner of the earth seems inexhaustible. Here is a well-illustrated book devoted to the Hebrides and dealing particularly with legend, archæology, verifiable history and local anecdote, written in the author's unhurried style without plan or system. There is a great deal of valuable record in this book, though any one fact would take a lot of finding, despite the index. One does not grumble at this in a writer who has always gone his own way, and by whom we would always prefer to be entertained rather than be instructed.

Because he is unique, we can bear that Seton Gordon should wear the rose-coloured spectacles, though he has had his imitators, who happily do not last. It is amazing that he can wander still enchanted through this haunting and haunted land which is one of the most devastated areas of Europe. One can read here incidentally of the burning of the forest on Raasay in the course of a Viking raid, but not of the immense ecological impact of forest destruction in the Highlands and Islands through a thousand years. The Vikings began it, political feuds and iron-smelting continued it, the eighteenth century accelerated it, and the two World Wars of our own time finished it. The "coming of the sheep" in the eighteenth century prevented the regeneration of forest, and the widening cattle/sheep ratio set in train a deterioration of the habitat which is to-day the root cause of the Highland problem and the basis of some of Seton Gordon's beautiful laments. Let us enjoy this book unreservedly, putting it by the bedside and remembering the beauty of Nature and of human nature which the Hebrides reveal; but when we rise in the cold light of the morning we should not forget the terrible scourge of sheep and rabbit, and the loss of cover and absorbent mould which could deal with a hundred inches of rainfall. A moor of *Scirpus* sedge in the dusk of an October day is indeed lovely: it is then the deer's hair grass, an auburn pelage; but the ecologist who has delved deep enough sees it as a degraded biotic climax brought about by continuing misuse.

The book is full of information of one sort and another of the ways in which a people meet the challenge of a difficult environment; for example, a Soay man going home lights a fire across the sound at Elgol in Skye—in the words of the country, "puts up a smoke"—so that a boat shall put across for him. But this is not all; he makes the fire on the knoll traditionally used by his family, and the right boat puts out. The telephone could do little better and the smoke is cheaper. At the other extreme, nobody could be more air-minded than the Hebridean, and the air ambulance is the accepted means of evacuating the desperately ill.

There is also described that important social habit and conservation measure of going to the shieling. It persists in Barvas, Lewis. The younger folk go to the moors in May or June with the livestock, and the older people remain at the crofts to tend the crops until harvest. Thus the herbage around the townships gets some respite, and the higher grazings are used. The young population at the shielings enjoyed a freedom impossible in the presence of the old, for nowhere is the commandment to honour father and mother more scrupulously kept. The demands of education cut across the desirable continuance of the shieling life, just as other exigencies of modern life render uneconomic those forms of cultivation in this countryside which helped in its conservation.

F. FRASER DARLING

MICROSCOPY

Die Grundlagen der Theorie des Mikroskops

Von Dr. Kurt Michel. (Physik und Technik, Band 1.) Pp. xi+314. (Stuttgart: Wissenschaftliche Verlagsgesellschaft m.b.H., 1950.) 27 D. marks.

Le contraste de phase en optique et en microscopie

Par Maurice Françon. Pp. 109+6 plates. (Paris: Éditions de la *Revue d'optique théorique et instrumentale*, 1950.) 480 francs.

Das Polarisationsmikroskop

Eine Einführung in die mikroskopische Untersuchungsmethodik durchsichtiger kristalliner Stoffe für Mineralogen, Petrographen, Chemiker und Naturwissenschafter im Allgemeinen. Von Prof. Conrad Burri. (Lehrbücher und Monographien aus dem Gebiete der exakten Wissenschaften, 25: Chemische Reihe, Band 5.) Pp. 308. (Basel: Verlag Birkhäuser, 1950.) 32.80 Swiss francs.

IN spite of all that has been written about the microscope, the increasing use of the instrument in numberless fields of inquiry has maintained a lively interest in its theory. The development of dark-field illumination, followed by the introduction of phase-contrast methods and the still more recent electron microscopy, have created a new demand for exposition. While the work of Helmholtz, Abbe, Rayleigh and others had laid the foundation on which a satisfactory theory could be constructed, it was only too clear that much remained to be done, and various writers such as A. E. Conrady and M. Berek have striven to lay down principles for the guidance of practical workers. It is probable that perhaps the majority of users of the instrument still have not sufficient acquaintance with the theory to attain either the best performance in operation or the best possible interpretation of the results. Therefore, any modern book purporting to deal with the theory of the microscope will be greeted with considerable interest.

Dr. Kurt Michel, who collected the material for his "Die Grundlagen der Theorie des Mikroskops" during a ten-year period with the firm of Carl Zeiss (Jena), has had excellent opportunities of contact with such masters as A. Köhler and others; and he approaches the topic mainly from the point of view of the physicist. Two-thirds of the book is taken up with a very comprehensive review of basic physical and geometrical optics, vision (including colour vision), photography and the like. The mathematics is limited to elementary algebra and trigonometry except for one or two simple integrals. Good descriptions of the construction of various types of objectives, etc., are accompanied by aberration curves and much other information rarely found in books on the microscope. The whole is illustrated by numerous very clear diagrams, some in colour.

There are some minor errors (for example, the central foveal cones are well known to be much smaller than 5 μ), and there is some over-simplification. The highly important dependence of visibility on contrast ought to receive adequate attention in any thorough discussion of the basic problems of microscopy, and would surely be much more valuable to the worker than the description of the supposed mechanism of colour-vision according to Studnitz, whose views are by no means so well accepted as the text seems to imply.

The last part of the book is almost completely devoted to a painstaking discussion of the wave theory of optical image formation in the microscope, the distinction between the self-luminous and non-self-luminous cases being clearly drawn at the outset. The cases chosen for mathematical discussion relate to the classical two-dimensional cases, so that simple sine functions rather than Bessel functions are encountered. After the discussion of small apertures, the images of 'amplitude gratings' and 'phase gratings' are considered, and the various classical points of the Abbe principle are discussed in detail. The theoretical aspects of phase contrast are dealt with in this connexion. A section is devoted to the description of experiments of the type due to Abbe. Perhaps the most interesting parts of these employ natural objects, that is, lycopodium spores. The well-known experiments on *Pleurosigma angulatum* are not forgotten, and are illustrated by excellent photographs.

Ultra-violet microscopy is dismissed in two pages, and a short section gives some information on the principles of electron microscopy. Apart from the brief discussion of the theoretical aspects of phase contrast already mentioned, the matter is apparently not considered sufficiently important to be treated in any detailed manner. Reflecting microscopes are not mentioned. It will be clear that the author has probably not been in touch with the recent developments in microscopy outside Germany, which is a pity, since his remarks on them would have been worth reading. Within its limits, however, the work is a good contribution to the literature of the subject, and there are few who will not find within its pages useful additions to their knowledge.

The second work, namely, M. Maurice Françon's small book on phase contrast, is addressed to quite another class of reader and is mainly concerned with a concise presentation of the mathematical diffraction theory of phase-contrast and other allied methods. It can be recommended to those who wish to lay a sound foundation for further theoretical or experimental researches, though it is not intended for those who merely need an easy explanation or introduction to the experimental aspects of the subject. The book includes, however, brief descriptions and theoretical discussions of a number of experimental methods which are still little known, including such devices as M. Françon's own arrangement of the auxiliary hemisphere, the Lyot compensator, and various forms of polarizing phase-plates.

The diffraction theory leads, of course, to various more or less complex formulæ which can usually be interpreted only by numerical calculations. A great many curves illustrating such results are given in the text; but, while they are indispensable in obtaining a rational approach to the matter, it has to be confessed that many simplifying assumptions are necessary, and we are still a great distance from the point at which empirical methods in actual phase-contrast microscopy can be abandoned. Apart from this, however, special measurements, such as Françon and Taboury's estimation of the thickness of a monomolecular film of fatty acid, are now possible; they represent a considerable advance on the limits traditionally assigned to purely optical methods.

Much of the work described in the book is necessarily a preliminary study and thus suffers somewhat from brevity and occasional over-simplification. For example, the criterion of resolution, that is, the vanishing of the second derivative of the intensity curve at the mid-point in the line joining the images of two objects, may be admitted to apply to the case of actual luminous points; but surely, in discussing the resolution of the phase-contrast images of small depressions, etc., the criterion should not be applied without a discussion of the contrast of the whole image? A considerable amount of work is still required before any generalizations are admissible. M. Françon's work represents, however, an important stage in the development of the subject, and physicists will be grateful for this excellent monograph.

Prof. Conrad Burri's book on the polarization microscope is written with the intention of finding an acceptable compromise between the type of book which is mainly descriptive and qualitative and the immensely sophisticated mathematical treatments of the optics of crystalline media which bear small relation to practical requirements. The days are past when this subject was scarcely of much importance to those other than petrologists; the author remarks in his preface that ninety per cent of the students taking the introductory courses on the polarization microscope are chemists and biologists. Thus the whole treatment is conceived from a very general point of view. The mathematics required, however, scarcely ever goes beyond trigonometry and a few formulæ in analytical geometry, the results of any long analysis being quoted where necessary. It is characteristic that a discussion of the analysis of elliptically polarized light should find an early place. The book then proceeds to a very thorough description of the "Optical Indicatrix" and its applications. There is then a very thorough discussion of the polarization microscope and its accessories, and further sections deal with the principal experimental techniques.

Prof. Burri has had considerable help in the preparation of the book from the late Prof. M. Berek, of Wetzlar, whose death in October 1949 deprived the world of science of an important leader in the field of microscope optics; some details, due to Berek, have not been previously published elsewhere.

The book is lavishly illustrated by excellent line diagrams and half-tone blocks, and is altogether most attractively produced. Prof. Burri has not only taught practical classes in this subject for more than twenty years, but also has obviously spared no pains to keep himself informed of the latest developments, so that the book will be a very useful one to any teacher or advanced student of the practical sides of the subject. Perhaps a physicist, approaching the subject with a reasonable mathematical equipment, might have been grateful for a few mathematical appendixes giving the derivation of some of the formulæ, since even in the books on theory there is a gap between the cursory treatment in the average book on light and the very full discussions already referred to. However, it is clear that this volume will be a welcome addition to the literature available.

L. C. Martin

DATING LATE-PLEISTOCENE EVENTS BY MEANS OF RADIOCARBON*

By Prof. RICHARD FOSTER FLINT
Yale University, New Haven, Connecticut

GEOLOGISTS concerned with the Pleistocene epoch have made repeated attempts to determine the time elapsed since the occurrence of conspicuous events in Pleistocene history. Most attempts have consisted in extrapolating backward on the rates of processes that are still in operation. However, as each of these rates is variable, the estimates have involved errors that are uncontrolled and perhaps very large. Nevertheless, there has been apparent the human tendency to remember the figures while forgetting that they are only estimates.

The situation has been changed by radiocarbon, through a method developed by Libby and Arnold[1] at the University of Chicago. By means of this method, it has become possible to date certain kinds of fossil substances, and thus to date the stratigraphic horizons from which they were collected. The method is limited in total range, and is subject to certain errors, but it represents a long step forward.

Origin and Nature of Radiocarbon

Radiocarbon (^{14}C) is a radioactive isotope of carbon. It is produced in the upper atmosphere by the bombardment of atmospheric nitrogen by cosmic-ray neutrons. It reacts with atmospheric oxygen to form carbon dioxide, and in that form enters into all organic matter, as well as into all material exchangeable with atmospheric carbon dioxide, such as carbonate in sea water.

If it is assumed that the flux of cosmic rays has been uniform throughout the past 15,000 years or so, then the proportion of carbon-14 to carbon-12 on the earth—about one to one trillion—should be constant, because the rate of disappearance of carbon-14 through radioactive disintegration and the rate of its creation should have struck a balance. It is probable, further, that the ratio of carbon-14 to total carbon in living matter must be constant, because the carbon in organisms is in continuous exchange with atmospheric carbon. The probability of the constancy of these proportions is supported by analyses of living matter taken from various latitudes.

On the death of any organism, this steady state of exchange ceases. The carbon-14 in the organic matter is diminished, by its own radioactive disintegration, at a known rate, and is no longer replaced by fresh accessions as was the case during the life-time of the organism. Hence the specific activity of the carbon in the dead organic substance gradually diminishes below that of the carbon in living matter. The half-life of carbon-14 is 5,568 $\pm$ 30 years. If the specific activity of the carbon in dead organic matter is determined to within a small limit of error, from it the time elapsed since death can be calculated. Whether the dead organic matter consists of charcoal from a prehistoric hearth, peat from a postglacial bog, or a tree over-ridden by a former glacier, the resulting dates, if accurately determined, are of the greatest importance to geological and human history.

* Abstract of a lecture given at University College, London, on February 22.

The short half-life of radiocarbon limits the backward reach of the dating method. At the end of three half-lives, the specific activity of the element has become so small that it is difficult to measure it accurately. Hence, at present 20,000 years is the effective limit of the dates determined by radiocarbon. There is hope, however, that through an enrichment process now under development this limit can be increased considerably.

Method of Assay

The samples are collected with care, so as to ensure minimum contact with other carbon-bearing substances. If the material is wood or other plant matter, the sample must weigh at least 40–50 gm. when dry. It is converted to carbon dioxide by burning (thereby eliminating other radioactive elements). After further purification the carbon dioxide is reduced to carbon by burning with metallic magnesium.

The carbon is placed in a tube in a screen-wall counter having an elaborate system of shields, and its specific activity is determined automatically. The elapsed time since death is then computed from the value of the specific activity. Laboratory error varies with the time devoted to the counting process; in many of the samples determined it is less than 5 per cent.

The laboratory process is checked from time to time by assaying anthracite coal, which, being of the order of 250 million years old, has no appreciable specific activity. Negative results from assay of the coal indicate that no laboratory error caused by contamination has developed. The method was checked also by testing samples of ancient carbon-bearing materials of known dates, such as wood from dated Egyptian tombs, and 'dead' heartwood from ancient trees dated by growth-rings. The laboratory dates agree well with the dates earlier determined by other means.

The dating method developed by Libby, Arnold and their associates at the Institute for Nuclear Studies in the University of Chicago, with financing in part by the Viking Fund, is still in an experimental phase. During the past year it has progressed from the testing of knowns to the assay of unknowns. When the need for ancient materials for assay was felt, a committee was appointed jointly by the American Anthropological Association and the Geological Society of America to work with the discoverers of the method. The committee consists of Frederick Johnson (chairman), Donald Collier and Froelich Rainey as anthropologists, and R. F. Flint as geologist. This group has been active in procuring material and as a consultative body, a screening and priorities board for incoming samples.

Possible Errors

Collaboration between the laboratory and the committee has led to a better understanding of the various sources of possible error, from the collecting onward to the final counting process. These sources now appear to be at least six in number:

(1) Possible variation in the rate of cosmic radiation during the time period spanned by radiocarbon dating. However, the agreement between the radiocarbon dates and the historical dates of materials from ancient Egypt suggests that there has been no significant variation during the past 4,600 years.

(2) Error in the field, in fixing the true stratigraphical position of the sample. Here the laboratory results can act as a check on the field-worker.

(3) Post-depositional alteration in the ratio of radiocarbon to total carbon, by chemical exchange and by organic activity, including penetration by roots of modern plants. Unburned bone has given variable results; it is believed to exchange carbon easily while lying buried in the ground. In contrast, 'burned bone'—essentially charcoal, and almost indestructible chemically—has given consistent results. Carbonate in the form of shells has yielded results of varying accuracy, evidently owing to chemical alteration. However, experience with shells has not been extensive, and the possibilities of their use seem by no means exhausted. Wood and peat have given consistent, reliable results, regardless of whether samples had been collected from positions that were wet or dry.

(4) Pre-depositional variation in the ratio of radiocarbon to total carbon. For example, aquatic plants that derive their carbon in part from freshly dissolved ancient carbonates containing carbon-14 with diminished specific activity might yield falsely low age values.

(5) Contamination during or after collecting.

(6) Laboratory error, including contamination, counting, and mislabelling.

If we set aside unburned bone and shells, and consider only the wood, peat and organic mud that constitute most of the geological specimens assayed before the end of 1950, the resulting dates fall into the same relative position as the stratigraphical horizons from which the samples were taken. This could scarcely be the case unless the error involved in post-depositional alteration is of relatively minor importance.

General Results

At least three general results are embodied in the dates obtained thus far from samples of primarily geological character. (*a*) Most of the radiocarbon dates support the relative stratigraphical positions of the samples. This encourages belief in the reliability both of the laboratory method and of the stratigraphical determinations made before the laboratory work was undertaken. (*b*) The dates of events late in the Fourth Glacial age have proved to be much less than had been previously estimated or assumed. (*c*) Climatic changes in northern and western Europe seem to have coincided approximately with those in North America.

Two Creeks Horizon. Perhaps the most important radiocarbon date thus far obtained is that of the Mankato, the latest of the four glacial expansions that occurred during the Wisconsin (Fourth) glacial age in North America. This involves the Two Creeks horizon, a layer of peat and wood that separates the highest or Mankato glacial substage from the next-lower, Cary, substage. The peat layer is exposed in wave-cut cliffs of Lake Michigan in northern Manitowoc County, Wisconsin, about twenty-five miles inside the outer limit of the Mankato drift. According to meticulous studies made by Wilson[2], the peat, which is very thin, overlies varved sediments deposited in the glacial ancestor of Lake Michigan during Cary time. The peat is overlain successively by more lacustrine sediments and by Mankato till. Therefore the peat is post-Cary, but antedates the Mankato maximum. The entire section seems to record continuous deposition, without any erosional hiatus.

The peat represents a spruce bog, with ecological relationships similar to those found to-day in northern Minnesota, some two hundred miles north of the Two Creeks locality. The spruce wood occurs as stumps rooted in place and as logs splintered at their butt ends and lying pointing towards the south-west, the direction of flow of the Mankato glacier. The splintering is of the kind characteristic of green wood; hence the forest was living up to the time when it was destroyed. Many of the logs record, through their growth rings, a decrease in rate of growth during the last few years of their lives.

The implied sequence of events is as follows. Late in Cary time the ice sheet shrank back, its southern edge bathed in lake water that occupied the basin of Lake Michigan as rapidly as the glacier uncovered it. When the glacier shrank back north of the Strait of Mackinac, the lake in the Michigan basin was at least partly drained—enough for the Two Creeks locality to emerge. Thereupon a spruce forest took root. After a time of growth, the forest was flooded by a new lake ponded in front of the advancing ice, and within a few years the glacier itself arrived on the scene, overwhelmed and splintered the forest by a giant process of bulldozing, and buried the site beneath till as the glacier margin advanced to its extreme limit twenty-five miles beyond Two Creeks. This was the Mankato advance.

The whole sequence, from Cary lake deposits through spruce forest to Mankato till, appears to be conformable. It represents an interval of possibly no more than a few hundred years. Both the implied short interval and the ecology of the bog suggest that deglaciation was not extensive; the ice-sheet margin may have retreated no farther north than the sites of the northern shores of the existing Great Lakes.

The radiocarbon dates of five samples of logs, stumps and peat agree closely enough at an average figure of 11,400 $\pm$ 350 years. Hence, the Two Creeks horizon, being closely fixed stratigraphically as representing the Cary–Mankato interval, and being also closely fixed in time, can properly serve as a key horizon to which other features can be related. For this reason its date appears as the most important of this first group of radiocarbon results.

The Mankato maximum must be younger than the time of destruction of the spruce forest by the number of years required for twenty-five miles of glacial advance. This can only be estimated; an estimate of 200–400 years seems reasonable, giving us a round figure of 11,000 years for the Mankato maximum. As the position of the Mankato drift border is known throughout an east–west distance of more than a thousand miles, the date of the Mankato maximum is widely useful.

Allerød Horizon. The very late Pleistocene horizon known as Allerød, occurring in many European peat bogs and lake deposits, gives evidence through its content of fossil pollen that it represents a time of warmth separating two colder times, and so by inference a time of glacial retreat, although unlike the Two Creeks peat it is not covered with till. It

underlies Zone III of the pollen stratigraphers. Thanks to H. Godwin and F. Firbas, it was possible to determine the radiocarbon dates of samples of the Allerød from four localities in Ireland, England and Germany. The dates are fairly close together, with an average of 10,767 years. This figure is close enough to the Two Creeks date to suggest that Allerød and Two Creeks represent a single warm phase that was felt on both sides of the Atlantic Ocean.

Pine-Pollen Zone in Eastern United States. The best marked and most widespread of the layers that constitute the pollen-stratigraphical sequence in North America is Zone *B*, a pine zone, overlying spruce and fir, and generally underlying oak and other deciduous types. It represents the earliest post-glacial development of a warm and fairly dry climate. Following the shrinking ice sheet, this zone should be of progressively younger age with increasing latitude.

Radiocarbon dates on five samples assembled by E. S. Deevey, jun., confirm this deduction. Three of them constitute a sequence on the Atlantic slope :

Location	Date (round numbers)
Cranberry Glades, West Virginia	9,500 years
New Haven, Connecticut, about 400 miles farther north	8,300 ,,
Aroostook County, Maine, about 400 miles still farther north	6,000 ,,

The other two samples constitute a sequence in Minnesota :

Anoka, near Minneapolis	8,000 years
Ely, 220 miles north-east of Anoka	7,100 ,,

It is interesting to note that all five samples post-date the Mankato maximum.

Glacial Great Lakes. Another group of three samples, which also postdate the Mankato maximum, are related to each other because of their relationships to the glacial Great Lakes. They provide dates for events late in the history of those Lakes.

The first sample is charcoal from a human occupation site in an island in Cayuga Lake, New York State. The site could not have emerged until well after Lake Iroquois, a glacial lake occupying the Lake Ontario basin, had begun to be drained. Geological evidence shows that Lake Iroquois was drained while Lake Algonquin III still occupied the western or upper Great Lakes region. Hence it is likely that at the time of the charcoal, 4,930 ± 260 years ago, Lake Algonquin III, with its northern shore of glacier ice, was still present.

The second sample is peat from beneath the surface of the present-day Lake Superior, near its western end. It is believed to have accumulated in a lagoon of the early phase of the Nipissing Great Lakes. The body of water would then be dated by the peat as having been in existence 3,656 ± 640 years ago. Subtracting this figure from the date of the charcoal, we get a difference of 1,274 years, the minimum elapsed interval between a time when Lake Algonquin III existed and a time early in the history of the Nipissing Lakes.

The third sample is a piece of an oak log occurring as driftwood in emerged beach sand and gravel, south of the city of Chicago. At this locality there is a complex of ancient beaches, all within a vertical range of about ten feet, representing three known lake-levels of different ages : (1) the Toleston strand-line of Lake Chicago, (2) the latest strand-lines of Lake Algonquin III, and (3) the latest strand-lines of the Nipissing Lakes.

The radiocarbon date of the wood, 3,469 ± 230 years, helps to fix the correlation of the enclosing beach. The date is far too young for Toleston Lake Chicago, which long antedates Lake Algonquin. It is also too young for Lake Algonquin III, dated by the charcoal as 4,930 years. It is slightly younger than the early Nipissing phase measured by the peat sample. Of the three geological possibilities, therefore, radiocarbon indicates latest Nipissing as the probable age of the beach containing the driftwood log.

Subtracting the late Nipissing date from the early Nipissing date, we get 187 years as the time elapsed between them. If this seems short, we can take advantage of the specified errors in each of the dates, and thus obtain more room. Without doing this, we have :

Late Nipissing	3,469
Early Nipissing	3,656
Algonquin III (= Iroquois in part)	4,930
Toleston Lake Chicago (= Mankato maximum ?)	11,000 ?

This scheme rests only on four dates, and certainly must be regarded as tentative. However, the facts that two of the dates fit stratigraphical correlations made earlier, and that a third date closely fits one of the three possible correlations offered, encourage the belief that both the geological field-work and the radiocarbon dating are reliable.

If a number of successive strand-lines can be dated by means of driftwood, it may become possible to measure the rate of uplift of the crust as it responded to the removal of the great weight of the ice sheet.

Mt. Mazama. Crater Lake, in southern Oregon, occupies a great caldera created by the gigantic explosion and collapse of the former volcanic cone known as Mt. Mazama. The catastrophe had been estimated by geologists to have occurred about ten thousand years ago. The radiocarbon date of charcoal from a tree killed by the catastrophe is 6,453 ± 250 years. Thus it appears again that, if we accept the radiocarbon dates, earlier geological estimates have been too high.

Folsom Man. The Folsom culture, represented by no human fossils but by an abundance of stone dart-points of a peculiar type, has been recognized throughout a wide region in western North America. Estimates of the date of this culture have ranged up to more than 25,000 years.

The radiocarbon date of a piece of burned bone from an occupation site in the western part of the State of Texas, said to be associated with Folsom dart-points, is 9,883 ± 350 years. If accepted, this date would place Folsom man as having been in existence at a time slightly later than that at which the ice sheet, farther north, reached its Mankato maximum.

Lascaux Cavern. The Cavern of Lascaux, lately discovered in the Dordogne district of western France, with its outstandingly fine wall frescoes, has yielded one radiocarbon date. Charcoal collected by the Abbé Breuil and S. Blanc from beneath the floor of a low-level chamber was identified as having been derived from wood of the silver fir, which implies a cold-temperate climate. Associated with the charcoal were artefacts which competent opinion placed as not younger than Magdalenian *II*[3]. The radiocarbon date of the charcoal is 15,516 ± 900 years.

Conclusion

If supported by further work, the results obtained thus far from radiocarbon dating constitute perhaps the most important event in Pleistocene research since the recognition of multiple glaciation and the establishment of a pollen stratigraphy. The examples[4] mentioned above are samples of the kind of result radiocarbon dating can accomplish. Radiocarbon can supply the dates of glacial advances and of climatic changes recorded by pollen frequencies; it can establish intercontinental correlations; it can date a sequence of strand-lines or a volcanic eruption; and, of perhaps greatest human interest, it can provide a firm chronology of ancient man. The universal importance of radiocarbon dating lies in the two facts that such dating is *absolute* and *world-wide*.

The Geochronometric Laboratory, now being set up at Yale University with funds provided by the Rockefeller Foundation, expects soon to begin a systematic programme of dating by means of the method pioneered by Libby and Arnold.

[1] For example, Arnold, J. R., and Libby, W. F., *Science*, **110**, 678 (1949); **113**, 111 (1951), and references given there.
[2] Wilson, L. R., *Torrey Bot. Club. Bull.*, **63**, 317 (1936), and references cited there.
[3] Oral communication from the Abbé Breuil.
[4] These examples and many others are discussed more fully in Flint, R. F., and Deevey, jun., E. S., *Amer. J. Sci.*, **249**, 257 (1951).

CREEP-RESISTING ALLOYS FOR GAS TURBINES

ON February 22 and 23, a symposium on "High-Temperature Steels and Alloys for Gas Turbines" was held under the auspices of the Iron and Steel Institute in the rooms of the Institution of Civil Engineers in London. On the evening of February 21, Sir Frank Whittle had given the fifth Hatfield Memorial Lecture on the development of the aircraft jet engine, and the symposium provided an opportunity of reviewing the metallurgical progress to which his invention gave rise, and discussing the problems of the gas turbine at its present stage of development.

Sir Andrew McCance, past-president of the Iron and Steel Institute, in a brief introductory speech, emphasized that materials capable of withstanding stress at the highest possible temperature are essential for the improvements in the efficiency of the use of fuel that are vitally important for our economy. Mr. D. A. Oliver then occupied the chair. The opening paper of the symposium, by Dr. N. P. Allen, described the early history of the creep-resisting alloys, and gave an account of the efforts that were made between 1939 and 1945 in Great Britain, Germany and the United States of America to produce the alloys of which the jet engines were ultimately made. The subsequent papers, of which there were thirty-six, were devoted to British activities during and after the War, and are an invaluable source of information on all aspects of the subject. The meetings were well attended. The presence of a large group of foreign experts testified to the regard in which British work on gas turbines is held. It was pleasant to hear from the Swiss turbine builders of the reliance that they place upon materials supplied from Great Britain, and the forthright and informative contributions of the American speakers were very welcome.

There are now four principal classes of creep-resisting alloy. The austenitic nickel–chromium steels hold pride of place. They are separating into three types. When large forgings are required, and strength must give place to ease of production, a steel with about 18 per cent of chromium, 8 per cent of nickel, 1 per cent of niobium and 0·1 per cent of carbon is favoured. Much attention has been given to the properties of finished components, as distinct from the properties of experimental test bars, and the papers by Mr. H. W. Kirkby and Dr. C. Sykes gave unique and important information. The niobium for this steel is expensive, and becomes increasingly difficult to obtain. 'Austerity steels', in which the niobium is presumably replaced by a more abundant element having a similar effect, are being studied; but their compositions are not yet announced. For large castings, a steel with 25 per cent of chromium and 12 per cent of nickel tends to be preferred, as it solidifies with a partially ferritic structure and is more plastic just below the melting point than a fully austenitic steel. It is consequently easier to cast and weld. This steel contains carefully adjusted proportions of carbon, silicon and tungsten. Their importance was described in an interesting paper by Mr. J. I. Morley, which showed how, if the ferritic structure is too stable, the steel has low creep resistance and tends to form the brittle sigma constituent on cooling; whereas if the ferritic structure is not allowed to form, the steel has high creep strength but may contain brittle carbide networks. An intermediate condition is generally best, and may be varied slightly in one direction or the other according to the relative importance of creep resistance and toughness in the casting.

When the greatest creep resistance is necessary, the austenitic nickel–chromium steels are strengthened by additions of cobalt, molybdenum, niobium or titanium. The alloys made in this way can be hardened by precipitation, and complex heat-treatments are an essential part of their manufacture. They are also capable of improvement by suitable mechanical working. A detailed account of the 'warm working' process as applied to a typical steel of this class was given by Mr. G. T. Harris and Mr. W. H. Bailey, who showed how the amount of mechanical work and the temperature at which it is applied can be controlled so as to produce a material having both a high proof stress at the low temperature existing at the centre of a turbine disk, and a good resistance to creep at the high temperature existing at the rim. The iron in this class of alloy can be replaced by cobalt, with progressive improvement of the creep resistance. Mr. G. T. Harris and Mr. H. C. Child described how by systematic exploration an optimum alloy may be developed; but this alloy contains 45 per cent of cobalt, and the use of so much cobalt may be difficult to justify.

At present, when creep resistance greater than can be produced in austenitic steel is required, nickel–chromium alloys, precipitation-hardened with titanium and aluminium, are used. The work leading to their development was described for the first time in a paper by Dr. L. B. Pfeil, Dr. N. P. Allen and Mr. C. G. Conway. These alloys are well established in Great Britain, and their strength and freedom from exceptionally scarce elements suggest that they will maintain their place. They have been tested for periods up to ten thousand hours: whether

they will maintain their superiority for longer periods, up to a hundred thousand hours, is still open to question, and designers wish to be assured on this point. A hundred thousand hours have not yet passed since the alloys were first conceived, and they have since undergone many minor changes. The turbine designer is faced with the choice between materials that have been completely tested, and are therefore at least ten years old, and materials that are more recent, probably better, but less completely known. His desire for more information and for means of predicting the behaviour of alloys in the distant future is understandable; but there is no reliable way of making forecasts. Since there must be some limit to the amount of creep testing that can be done, it is very important to decide how much of the available effort should be devoted to the detailed testing of existing alloys, and how much to making the improvements that are surely possible.

Ferritic steels are used when the service temperature is not so high as to demand austenitic steels. Two types, containing respectively 0·5 per cent of molybdenum and 0·25 per cent of vanadium, and 3 per cent of chromium, 0·6 per cent of molybdenum, 0·8 per cent of vanadium and 0·6 per cent of tungsten, have received special attention, and have excellent creep resistance at temperatures below 600° C. Extensive tests on the latter steel were reported by Mr. H. H. Burton, Mr. J. E. Russell and Mr. D. V. Walker. A very recent development is the introduction of creep-resistant ferritic steels containing 10–13 per cent of chromium. These steels are resistant to oxidation, and therefore can be used at temperatures above 600° C., at which other ferritic steels fail. They compare very favourably in creep resistance at 600° C. and 650° C. with the first of the three above-mentioned classes of austenitic steel and, since they are more economical in alloying elements, may well replace them in some directions. It is curious that no highly creep-resistant steel has yet been developed with a chromium content between 3 and 10 per cent, although steels with 5 per cent of chromium are quite resistant to oxidation and would be very economical to use if the necessary high-temperature strength could be developed. An interesting paper by Mr. E. W. Colbeck and Dr. J. R. Rait suggested that the carbides found in steels of intermediate chromium content are not of a type favourable to creep resistance, but this may not be an insuperable obstacle.

The fourth type of creep-resisting material now in use comprises the range of cobalt-base precision-casting alloys. These alloys, which usually contain about 30 per cent of chromium and a moderate percentage of either tungsten or molybdenum, did not figure in the symposium as much as might have been expected. They are very costly, and although the results obtained in laboratory tests can be excellent, the alloys are not widely used for highly stressed components because of the difficulty of being certain of the reliability of castings. In Great Britain precision casting has been used principally as a method of making lightly stressed components, such as stator blades, in oxidation-resistant but relatively economical alloys.

A number of papers dealt with the problems of fabricating creep-resisting alloys, and it is clear that as much work has been required in solving these problems as in developing strength at high temperatures. We are, indeed, in the process of building up a workshop technique for creep-resisting alloys comparable with that which has been developed for the common engineering steels during the past hundred years. The gas turbine being built up of a series of rings, centrifugal castings have played a large part in its construction, and a rivalry between the centrifugal processes making use of metal moulds and those making use of sand moulds became apparent, the arguments being generally in favour of the use of the metal mould when applicable. Precision-casting processes are used for a variety of smaller shapes. The processes are interesting as being a revival of the ancient lost-wax process. They differ from the ancient process in being adapted, by an elaborate procedure, to the production of a large number of accurate replicas of the pattern, and in the use as mould materials of special refractories that can withstand the chemical attack of molten alloys at very high temperatures.

In the construction of large gas turbines for marine engines and electric generators, the arc welding of austenitic steel forgings and castings has proved difficult, and many references were made to the danger of cracks in welds. The cracks can be avoided by the use of suitable techniques and by the control of the silicon content of the weld metal. There is uncertainty about the mechanical properties of arc welds at high temperatures, though such information as exists is reassuring. The construction of flame tubes, jet pipes and ducts of many kinds in both austenitic steel and nickel–chromium alloy sheet has been accomplished by resistance welding with great success. As described by Mr. H. E. Lardge in a very informative paper, the distortion due to the high thermal expansion and low thermal conductivity of the alloys was overcome by welding with the smallest input of heat, and using effective means of cooling. The machining of creep-resisting alloys at first presented great difficulties, which were overcome by the skill and resource of the men in the machine shops, to whom the gas turbine owes a great deal.

The modern gas turbine has an inlet gas temperature of 650–800° C. or perhaps 850° C. Its thermal efficiency is rather low, and could be improved if the gas temperature were raised. Naval representatives at the meeting emphasized that higher efficiencies must be developed before gas turbines can be widely adopted in ships. The materials necessary to make higher working-temperatures possible are not yet in sight. Cobalt–chromium–tantalum alloys having promising strength at 900° C. were described by Mr. J. C. Chaston and Mr. F. C. Child: their use seems to be impossible under present economic conditions; but it must be remembered that several of the alloys that are now in use would have been considered fantastically expensive twenty years ago. Chromium-base alloys have been studied by Mr. E. A. G. Liddiard and Dr. A. H. Sully. They are too brittle, and no way of making chromium sufficiently tough has yet been found. Excessive brittleness also prevents the use of refractory oxides such as sintered alumina. It seems to be generally agreed that a certain amount of plasticity is essential in any practical material, as a protection against thermal shock, which can be very severe, and against excessive stress concentrations at changes of section. 'Ceramels', which are mixtures, made by the methods of ceramics, of refractory oxides or carbides embedded in a metallic base, were considered by some authorities to offer the most promising combination of properties. One speaker described engine tests on turbine rotor blades made of a ceramel consisting essentially of

titanium carbide bonded with nickel or cobalt, in which the creep resistance of the material had proved to be adequate; but failure had resulted from insufficient resistance to the stress concentrations in the blade root. Confidence in this type of material has not yet been established, and its future seems to depend on the achievement of sufficient plasticity without loss of creep resistance.

The alternative way of achieving high inlet gas temperature is to cool the critical metal parts. The problem then is to secure the greatest effective cooling with the least loss of heat and energy in the cooling agent. There is little doubt that the most effective device is to interpose a stable blanket of cool gas between the hot gases and the surface to be cooled. Mr. P. Grootenhuis and Mr. N. P. W. Moore described how this can be done by leading a small quantity of liquid continuously to the surface through fine pores provided in the component. This is known as 'sweat cooling'. It can be readily applied to lightly stressed components, but not so easily to severely stressed components. It is possible that in view of the need for conserving scarce metals, and the improbability of a large and swift improvement of the available alloys, the correct policy for the next few years will be to stabilize the main types of creep-resisting alloy and concentrate upon the efficient use of cooling.

The second problem of the gas turbine is to increase the useful life of the engine from the thousand or so hours demanded of the aircraft engine to the ten thousand or hundred thousand hours required for most industrial applications, while at the same time adopting a cheap fuel, such as heavy fuel oil or pulverized coal. The need for more data on the behaviour of the new alloys over extended periods of time was repeatedly stressed. The difficulty of providing this information while the alloys themselves are being modified continuously has already been mentioned, and furnishes an additional argument for standardizing the alloys as soon as it becomes possible to do so. It was mentioned, however, that the performance of the gas turbine will be seriously diminished if unnecessarily long service lives are insisted upon. The use of cheap fuel introduces the danger of corrosion of the engine by the mineral constituents of the fuel, particularly by the fusible vanadium salts that are present in many fuel oils. Metallurgists could hold out no hope of finding a serviceable alloy that would resist contact with partially molten fuel ash, and looked to the oil technologists to remove, or render harmless, the objectionable constituents of the oil; but the oil technologists could suggest no method cheaper than distillation. It is to be hoped that the last word has not yet been said on this subject. Gas turbines have run successfully for short periods on vanadium-containing fuel oils without serious effects. Much can be done to minimize the danger of corrosion, and it may be that the importance of the problem is exaggerated; but it undoubtedly gives rise to much anxiety.

The immediate future appears to demand the detailed improvement of the existing types of alloy, as a result of which a gradual rise of the strength and reliability of components of all kinds will no doubt take place. The shortage of many essential metals overshadows the situation, and it will be necessary to ensure that the strongest alloys are not used where weaker ones would do, and that no excessive amounts of scarce elements are employed even to meet the most onerous conditions. A prolonged struggle between the more advanced ferritic alloys and the less developed austenitic alloys for use at temperatures between 550° C. and 650° C. is to be expected, with the austenitic alloys gradually yielding place. In view of the complexity of the alloys, all this work will call for a vast amount of metallurgical experiment and mechanical testing. How much improvement is to be expected? The opinion was expressed that the possibilities of the austenitic solid solution alloys based on iron, nickel, chromium and cobalt are approaching exhaustion; and although a somewhat similar opinion was expressed in 1924, it now seems rather unlikely that the temperatures to which these alloys will maintain their strength can be much increased. Improvements of the reliability with which the best properties can be secured are more probable. Some major discovery seems to be required before the service temperatures of gas turbine materials can be greatly increased: it will no doubt be made, but how and where cannot yet be foreseen.

N. P. Allen

OBITUARIES

Prof. V. F. K. Bjerknes, For.Mem.R.S.

Prof. Vilhelm F. K. Bjerknes, foreign member of the Royal Society, honorary member and Symons Medallist of the Royal Meteorological Society, who died at Oslo on April 9, 1951, was the doyen of meteorologists. V. Bjerknes, as he was generally known, was born on March 14, 1862, the son of C. A. Bjerknes, professor of mathematics at Christiania, himself a pioneer in the investigation, theoretical and experimental, of fluid motion. V. Bjerknes, during his education at Christiania, assisted in his father's investigations and afterwards worked in Germany under Hertz. He became specially interested in the (apparent) action at a distance of solids moving in a circulating fluid and the analogies with electrodynamics. After his appointment in 1893 as professor of mechanics and mathematical physics at Stockholm, he prepared his first important work, lectures on "Hydrodynamische Fernkräfte", issued in two volumes during 1900–2. He was later to indicate in a lecture at the Royal Institution in May 1924 the analogy between the forces on a rotating cylinder moving through a fluid and the forces on an aeroplane due to the circulation induced by the asymmetry of the wing. The forces, lifting the cylinder, at quite moderate speeds are substantial and can be exactly controlled by adjusting the speed of rotation.

In 1898 Bjerknes introduced into dynamical meteorology the concept of 'solenoids', the tubes formed by the intersection of a system of isobaric surfaces at unit intervals with a system of isosteric (equal specific volume) surfaces also at unit intervals. He showed that if C is the circulation around any closed circuit, $dC/dt = N$, the number of solenoids intersecting the circuit. He deduced that, for a fluid in equilibrium, N must be zero, and that if N is not zero, the induced circulation is in the direction which will bring the isobaric and isosteric surfaces into coincidence (or parallelism). Bjerknes thought at first that this would have very wide meteorological uses and he applied it to the sea breeze and the Indian monsoon. But he soon realized that the effect of the rotation of the earth, though small in the initial development of motion from rest, became of

great importance in the major movements of the atmosphere, and that he must include with N a term $-2\omega \frac{dS}{dt}$, where S is the area of the projection of the circuit on the equatorial plane and ω is the angular velocity of rotation. He did this in 1901, and pointed out the fundamental deduction that a circuit acquires cyclonic or anticyclonic circulation according as it contracts or expands.

From this time, for the next twenty years, Bjerknes devoted his energies to the problem of approximate integration of the equations of motion of the atmosphere (and the ocean) as a necessary preliminary to a practical scientific method of forecasting weather. In this he had the assistance first of J. W. Sandström and then of many other collaborators, notably Th. Hesselberg, and from 1906 he received financial assistance for his investigations from the Carnegie Institution of Washington. There resulted "Dynamical Meteorology and Hydrography", a treatise designed to present in an ordered and rational form the principles and the practical aids to the development of meteorology and hydrography from the point of view of a mathematical physicist. The treatise was planned in three volumes; but only two were completed and issued, in 1910 and 1912. It emphasized the importance of a universal co-ordinated system of units and included the proposal, first put forward in 1906, to use absolute units of pressure, and introduced the terms 'bar' (megadyne per cm.^{2}) and 'millibar' as the practical units for hydrography and meteorology respectively. The millibar has now become established throughout the world in meteorology and aviation, though not yet in physical laboratories, still wedded to the mercury inch and mercury millimetre. The treatise included also the first explicit statement of the important result that the distance between contour lines on an isobaric surface in the atmosphere is an inverse measure of the geostrophic wind, independent of the density of the air. This has been the main factor in influencing meteorological services to use contours on isobaric surfaces instead of isobars on geopotential surfaces in the practical application of upper air observations.

Bjerknes had left Stockholm for Christiania in 1907, and five years later he went to direct the new Geophysical Institute at Leipzig. He gathered around him a band of workers and initiated two series of publications; one of actual synoptic situations and the other of special researches, notably those by Hesselberg and Sverdrup, and, in later years, of Bergeron and Swoboda. The First World War took away his ten German assistants—half of them were killed—and in 1917 he left Leipzig for Bergen. He had already, in a lecture in London in 1910, emphasized the value of charts of stream lines in revealing lines of convergence. Their further application, begun at Leipzig and continued at Bergen, led to the development of frontal and air-mass meteorology, including the polar front and the structure of cyclones. These have played an outstanding part in meteorology in the past thirty years. Bjerknes freely acknowledged the contribution of Bergeron, Solberg, and his son, J. Bjerknes, to this development; but he was himself the architect of the building and the inspirer of the workmen. In 1920 he and Helland Hansen arranged a meeting in Bergen with British meteorologists, including Sir Napier Shaw and Dr. L. F. Richardson, and the discussions were renewed in 1921 at a meeting of the International Upper Air Commission, of which Bjerknes was president. The enthusiasm of the 'Bergen' School was infectious and inspiring.

In 1926 Bjerknes left Bergen, where the work was continued by his pupils and whither meteorologists from all over the world were drawn. He returned to his former chair at Christiania (now Oslo), and with the collaboration of Solberg, J. Bjerknes, Bergeron and Godske completed and published the three-volume treatise on "Hydrodynamics and the Applications to Meteorology", issued in 1933–34, which stands as his permanent memorial. He retired in 1932, but continued to take an active part in international meteorology. He presided over the fruitful meetings of the Association of Meteorology of the International Union of Geodesy and Geophysics at Edinburgh in 1936. He lived in Oslo during the German occupation, sad but courageous. In 1946 he paid his last visit to England, when he and Prof. C. Størmer were the two delegates from Norway to the Newton Tercentenary Celebrations of the Royal Society. In the summer of 1948 he was looking forward cheerfully to his winter ski-ing.

Bjerknes was dignified in manner, in appearance and in his presentation of his scientific work; but with his dignity he combined a certain modesty and an unfailing attraction and stimulus to younger men. Through them his influence on meteorological development has been outstanding in the meteorological services of all nations.

Bjerknes married, in 1893, S. H. Bonnevie, whose gracious and warm-hearted hospitality at the Bergen meetings of 1920 and 1921 was a fitting, well-remembered counterpart to the scientific enthusiasm of Bjerknes and their son, Prof. J. Bjerknes, to whom meteorologists throughout the world will wish to tender their respectful sympathy in his loss.

E. Gold

Mr. H. St. J. K. Donisthorpe

Horace St. John Kelly Donisthorpe, who died on April 22, was the sole survivor of the 'great five' of myrmecology. In the period between 1850 and 1950 immense advances were made in the study of ants. These embraced practically every field: the re-organization of their taxonomy, the study of their distribution, their life-history, polymorphism, and behaviour. Thousands of papers were produced and more than ten thousand new species were described during this period. The inspiration behind all this work was the existence of five great students of ants, Auguste Forel in Switzerland, Wasman in Holland, Wheeler in America, Emery in Germany, and Donisthorpe in Britain. Each one was an amateur.

Donisthorpe published his first paper on ants in 1908. Since then he has published more than three hundred papers reporting his studies on ants. His book, "British Ants", first published at his own expense in 1915 and re-published considerably enlarged and amended in 1927, is still the book to which anyone seeking knowledge about the ants of Britain must turn.

To-day, Donisthorpe is remembered chiefly as a taxonomist. He always sought to encourage people to study ants, and he would go to any lengths to help them to make their studies more accurate and worth while. In his early days, he spent much time studying the behaviour of ants, especially their slave-making and the way in which the queen ants (females) found new colonies.

At the same time, most of Donisthorpe's knowledge of ant behaviour was learnt in the field in the manner of the old school: it was learnt by his wanting to know more about their habits because he wished to collect more specimens or obtain the queens.

Personally, Donisthorpe was a great character. The last time I saw him he recounted again with pride how in his twenties he had swum across the Rhine near Heidelberg, a feat which, so it was said, no one had achieved before. Lately, he persevered in his attempts to continue going to the British Museum (Natural History) each day, or at least for some days each week, until his death.

Derek Wragge Morley

NEWS and VIEWS

Mathematics at Birmingham: Prof. G. N. Watson, F.R.S.

The chair of mathematics in the University of Birmingham will be vacated at the end of the present session by Prof. George Neville Watson, who has held it since 1918. Prof. Watson, who was born in 1886 and educated at St. Paul's School and Trinity College, Cambridge, was senior wrangler in 1907 and became a Fellow of Trinity in 1910. He was elected to the Royal Society in 1919 and became successively president of the Mathematical Association in 1932 and of the London Mathematical Society in 1933. He is a Gold Medallist of the Danish Royal Academy of Sciences, and among other distinctions is an honorary LL.D. of the University of Edinburgh. Prof. Watson's name first became known by several important memoirs on asymptotic series, which were followed by a series of papers in which he found asymptotic expressions and approximations for all sorts of functions by the method of steepest descents (a term coined by him and which is now standard). About 1917 many of the ablest mathematicians were attempting to sum a difficult series which had presented itself in connexion with the diffraction of wireless waves around the earth. Prof. Watson solved the problem, and went on to study the transmission of electric waves when it is assumed that the earth is surrounded by a concentric conducting layer. Other celebrated researches were concerned with general transforms and the Rogers–Ramanujan identities. Prof. Watson is well known to all honours students of mathematics by two books, "Modern Analysis" (written in conjunction with Sir Edmund Whittaker) and the "Theory of Bessel Functions", perhaps the most important single work that has ever been written on the analysis of functions.

Dr. R. A. Rankin

Prof. Watson is to be succeeded by Dr. Robert A. Rankin, at present lecturer in mathematics in the University of Cambridge. From Fettes College Dr. Rankin went up in 1934 to Cambridge, where he is now a Fellow of Clare College; he was a wrangler in 1936, and took a distinction in Part 3 of the Mathematical Tripos the following year. He started on a research career in the field of the theory of numbers, and five papers appeared before the end of 1940. Shortly after the outbreak of the Second World War, groups of research students were recruited to defence departments to expand their limited effort, and Dr. Rankin was among the first team to join the relatively new Projectile Development Establishment of the Ministry of Supply, formed to develop rockets. The theory of numbers was scarcely applicable, but his quality as a mathematician was soon obvious, first in day-to-day development problems of rocket weapons, and later in a more fundamental way. He became a leading member of Prof. L. Rosenhead's ballistics branch and was to put on a firm foundation the mathematics of rocket theory, particularly that of spinning rockets. This work has been published (*Phil. Trans. Roy. Soc.*, A, 241, 457; 1949) and places on record a paper comparable to that of Fowler, Gallup, Lock and Richmond on the spinning shell, which was the fruit of research of the First World War. Since then Dr. Rankin has returned to the theory of numbers, and has already to his credit a long list of research papers on the differences between consecutive prime numbers and the properties of the coefficients of modular forms. More recently he has turned his attention to problems in linear forms and has discussed such problems as the packing of convex bodies and associated problems in the geometry of numbers.

United States Office of Naval Research

Dr. Emanuel R. Piore has recently been appointed deputy and chief scientist of the United States Office of Naval Research, in succession to Dr. Alan T. Waterman, now director of the National Science Foundation. Dr. Piore graduated in physics from the University of Wisconsin in 1930 and took his Ph.D. there in 1936. During 1938–42 he was engineer in charge of the television laboratories of the Columbia Broadcasting System, interesting himself in the development of colour television. After service during the Second World War as a senior physicist in the Navy's Bureau of Ships and then in the Navy Reserve as a lieutenant-commander, he joined the Office of Research and Inventions (later to become the Office of Naval Research) in 1946 as head of the electronics branch, and since 1949 he has been deputy for natural sciences. Dr. Piore's previous post at the Office of Naval Research has been filled by Dr. Randal N. Robertson, formerly director of the Physical Sciences Division of the Office. Dr. Robertson will be responsible for research in the earth, physical and mathematical sciences. He went to the Office of Naval Research in 1946 from the Radiation Laboratory of the Massachusetts Institute of Technology, where he had been engaged in war-time research and development of airborne radar bombing systems.

"Science News"

Several recent articles have commented on the outstanding advances in science and particularly in physics made during the past fifty years and on the profound effect these advances have had on our everyday life. The importance, both to industry and to science, of informing, without undue delay, as wide a public as possible of the investigations being undertaken by men of science, of the results obtained and of their implications has been correctly emphasized. Whereas the scientific periodicals of the various professional bodies have for long catered for the specialists and research workers, it is only com-

paratively recently that a scientific Press serving the non-specialist has appeared. For the general public, most newspapers now have on their staffs journalists, some of considerable merit, who regularly report on the progress of science. It is to be expected that, though their reporting is usually accurate, it is often highly coloured and somewhat exaggerated to cater for popular taste. However, between the two extremes of the specialist and the general newspaper reader, there is a large public consisting of educated laymen with wide interests who require something which is more detailed than the newspapers can give but which, while presented in a serious, authoritative, concise and interesting manner, should yet avoid the terminology and preciseness of the specialist article.

In June 1946 the first number of "Science News" appeared, and it was at once acclaimed as a welcome and important addition to the then available scientific literature. It satisfied the particular and peculiar need of the specialist interested in what is going on in branches of science other than his own, and of the educated layman. The fact that No. 1 has since been followed at brief intervals within the past five years by no less than eighteen further issues in the series is sufficient indication of their considerable popularity and undoubted success. The publishers are to be congratulated on their enterprise, and the editor, Dr. J. L. Crammer, for devoting his spare time and considerable energy to the promotion of such a worthy object and with such remarkable success. No. 19 in the series of "Science News" (Harmondsworth: Penguin Books, Ltd., 1951; 1*s.* 6*d.*) records that a new editor has been appointed, namely, A. W. Haslett, who, as a frequent contributor to "Science News", the editor of the weekly *Science To-day*, science broadcaster and author, is well known as a science journalist. His wide knowledge, his many contacts in the universities and research laboratories and his deep appreciation of scientific truth are particularly mentioned in the editorial of No. 19 as qualities which will ensure that under his guidance "Science News" will maintain its already high standard.

Lord Rutherford: An Appreciation

The text of the Fifth Rutherford Lecture of the Physical Society, delivered before the Society by Dr. A. S. Russell, of Christ Church, Oxford, on December 8, 1950, has recently been published (*Proc. Phys. Soc.*, A, 64, 217; March 1951). Describing himself as an inorganic chemist and a former pupil and admirer of Lord Rutherford, Dr. Russell not only gives his impressions of Rutherford as a man and physicist, but attempts also to explain why it was that the inorganic chemists were so slow, in the years preceding 1914, in arriving at the conceptions of isotopes and atomic number. The years 1907–19 which Lord Rutherford spent at the University of Manchester are described as "the great middle period of Rutherford's life of discovery". Many famous physicists, including Chadwick, Darwin, Marsden, Nuttall, Robinson and the brilliant Moseley, were members of his staff. He had the co-operation for a time of Niels Bohr, and many notable men of science from other universities came for long or short periods to work with him at Manchester.

Dr. Russell refers only briefly to Rutherford's scientific achievements, for they have been described in detail elsewhere. It is, however, by well-chosen illustrations and anecdotes that Dr. Russell brings out clearly the remarkable qualities of the great man: Rutherford's foresight and penetration, in addition to good fortune; his insight into scientific problems; his great experimental skill; his exuberance when off duty and his seriousness at work; and, over all, his kindness and generous outlook on life. Finally, Dr. Russell considers the general question of the paramount importance of the 'great man' in science. It is his belief that we cannot afford in science not to know anything that possibly can be discovered, and that in the pursuit of knowledge we cannot afford to do without the 'great man'. The team of talented workers may finally make some great contribution to science, but the more fundamental the science, Dr. Russell asserts, the greater is the need for the big advances which only great men can make. Rutherford "by probing the atom to its very depth not only revealed great truth and great beauty; he showed us by example what one man can do when he makes the most of his great gifts".

Centaurus: a New Quarterly on the History of Science and Medicine

An indication of the steadily growing interest in the history of science and medicine is given by the appearance, in Denmark, of a new quarterly journal, *Centaurus*, an addition to the not very extended ranks of the periodical literature on these subjects. The journal is published by Ejnar Munksgaard, of Nörregade 6, Copenhagen, and the general editor is Jean Anker, director of the Scientific and Medical Department of Copenhagen University Library, who is assisted by a board that includes a number of associate editors drawn from various European countries, North America and elsewhere. The first two numbers contain thirteen original articles, rather more than half of which are of medical interest. Additional matter is included under the headings: varia, book reviews, list of books received, and obituaries. The quarterly is well printed on good paper and adequately illustrated. The editorial board appears to have set a high standard for this new publication, and it should receive a welcome in Great Britain. Of particular interest to British readers, whose linguistic attainments are generally more limited than those of Continental readers, is the fact that it is laid down that all articles must be written in one of three languages: English, French or German. In fact, five of the thirteen articles in Nos. 1 and 2 are written in English. The annual subscription, about 44*s.* post paid, at the current rate of exchange, seems reasonable for these times.

Human and Natural Laws in China and the West

In his Hobhouse Memorial Trust Lecture, delivered on May 23, 1950, at Bedford College, London, and now published (Hobhouse Lecture No. 20; pp. 44; London: Oxford University Press, 1951; 2*s.* 6*d.* net), Dr. Joseph Needham traces the development of the ideas of human law and the laws of Nature in Europe and then reviews Chinese thought on this subject, with the object of discovering whether there is anything which could properly be classed among the factors in Chinese civilization which inhibited the indigenous rise of modern science and technology. He concludes that the great distaste of the Chinese for precisely formulated, abstract, codified law, the relatively greater importance of the element of natural law in Chinese than in European society, and

the early depersonalization of available ideas of a supreme being and their lack of ideas of creativity, all prevented the development of the conception of the laws of Nature from Chinese conceptions of law in general. Moreover, the concrete forces of Chinese social and economic life were not sufficiently favourable to science to overcome such inhibiting factors.

Traditional Colonial Art: Exhibition at the Imperial Institute, London

An exhibition of traditional Colonial art has been arranged in the Art Gallery of the Imperial Institute, South Kensington, London, S.W.7, and will be open to the public until September 30 (weekdays, 10 a.m.–6 p.m.; Sundays, 2.30 p.m.–6 p.m.). The exhibition presents only work from Colonial territories of the British Commonwealth which is authentically traditional, thus excluding articles made for export or for sale to the tourist and such modern work as is produced under external influence; the selection of the work displayed has been governed by æsthetic considerations, and the exhibition is not planned as an ethnographical or anthropological study. The exhibition is divided into two sections, the larger being devoted to sculpture, and the smaller to such crafts as pottery, basketwork, textiles and other forms of cloth, metalwork, etc.

Commonwealth Fund Fellowships

Commonwealth Fund fellowships, tenable by British graduates in American universities for one year beginning in September, have been awarded to the following, among others: A. C. Allen, Queen's University, Belfast, and Peterhouse, Cambridge (mathematics); H. Davies, Jesus and Merton Colleges, Oxford (theoretical physics); M. W. Dick, Balliol College, Oxford (symbolic logic); M. J. Farrell, New College, Oxford, and King's College, Cambridge (economics); R. P. Jepson, University of Manchester (experimental surgery); M. S. Longuet-Higgins, Trinity College, Cambridge (oceanography); W. S. Owen, University of Liverpool (metallurgy); K. V. Roberts, King's College, Cambridge (theoretical physics); O. Smithies, Balliol College, Oxford (physical chemistry); B. A. D. Stocker, University of London (bacteriology); L. E. Weiss, University of Birmingham (geology). Dominion and Colonial Civil Service Fellowships of the Commonwealth Fund, tenable by Civil servants from the British Commonwealth, have been awarded to the following, among others, for study in the United States (not necessarily at a university): E. W. de Lisle, New Zealand (radio engineering); W. J. Gibbs, Australia (meteorology); K. G. E. Moody, Australia (civil engineering); C. H. de C. Murray, South Africa (psychology); S. F. Barnett, East Africa (veterinary science); S. Woolmer, Singapore (town planning).

University of London

Prof. P. B. Medawar, Mason professor of zoology in the University of Birmingham, has been appointed to the Jodrell chair of zoology and comparative anatomy tenable at University College, London, as from October 1, in succession to Prof. D. M. S. Watson. The title of reader in anthropology in the University has been conferred on Dr. Phyllis Kaberry, in respect of the post held by her at University College. The following doctorates have been conferred: *D.Sc.*: Mr. L. B. Holt (University College), Mr. R. A. M. Mackay (Imperial College of Science and Technology); *D.Sc.(Eng.)*: Mr. Guthlac Wilson (Queen Mary College).

Society for Endocrinology: Officers

Officers and the committee of the Society for Endocrinology have been elected as follows: *Chairman*, Dr. S. J. Folley; *Honorary Secretaries*, Prof. C. H. Gray and Prof. N. F. Maclagan; *Honorary Treasurer*, Dr. F. L. Warren; *Honorary Editor of the Society's Proceedings*, Dr. P. L. Krohn; *Ordinary Members of Committee*, Prof. E. C. Amoroso, Dr. G. W. Harris, Dr. C. J. O. R. Morris and Dr. E. F. Scowen. Communications should be sent to the Honorary Secretary of the Society, Department of Chemical Pathology, King's College Hospital, Denmark Hill, London, S.E.5.

Society for General Microbiology

Officers for 1951–52 of the Society for General Microbiology have been elected as follows: *President*, Prof. J. W. McLeod; *Meetings Secretary*, Dr. W. E. van Heyningen; *General Secretary*, Dr. J. G. Davis; *Treasurer*, Dr. R. Lovell; *Editors*, Prof. B. C. J. G. Knight and Mr. A. F. B. Standfast. The Society, which was founded in 1945, now has 985 members and will hold its September meeting in Manchester. Further information about the Society can be obtained from Dr. J. G. Davies, 35 Villiers Road, Southall, Middlesex.

"Biology in 'Chambers's Encyclopædia'"

In a review under this title published in *Nature* of April 21, reference was made to the point that, going through the sections letter by letter, certain topics were not found at the points expected. Mrs. M. D. Law, managing editor of the "Encyclopædia", states that, in fact, there is a section on biochemistry, by Prof. E. H. F. Baldwin, under 'B', and a paragraph on Canada balsam under 'C'; both were unfortunately overlooked by the reviewer. As regards the other comments on omissions under appropriate letters, Mrs. Law points out each one is dealt with at some point in the work, and can readily be found by reference to the general subject index in vol. 15, which is designed to guide readers to the heading including the topic under discussion.

A Giant Sunspot

The big sunspot reported in *Nature* of April 28 (p. 672) returned with renewed development to cross the sun's disk during May 9–22. When fully in view near the sun's east limb, the area of this complex group corrected for foreshortening was about 2,250 millionths of the sun's hemisphere, and by the time it had passed the sun's central meridian on May 16·0 U.T. the area had increased to 4,850 units, or about 110 times the cross-section area of the earth. A peak area of this value has been exceeded by only two other spot groups, and equalled by a third, in the photographic record of sunspots maintained by the Royal Greenwich Observatory since 1874. All these spots have occurred in the present 11-year sunspot cycle and appeared successively in February 1946, July 1946 and April 1947, the last attaining the remarkable area of more than 6,000 millionths. The first two groups were associated with intense solar flares followed by 'great' geomagnetic storms, in the first case 17½ hours, and, in the second, 26½ hours after the flares. The present spot showed little

tendency to produce flares up to the time of central meridian passage. On May 18, however, a major flare occurred from 10h. 18m. until about 13½h. U.T., and this was associated with a marked radio fade-out on long-distance radio communication.

The Night Sky in June

NEW moon occurs on June 4d. 16h. 40m. U.T., and full moon on June 19d. 12h. 36m. The following conjunctions with the moon take place: June 2d. 21h., Mercury 7° S.; June 8d. 18h., Venus 1° S.; June 13d. 07h., Saturn 4° N.; June 27d. 01h., Jupiter 4° S. Mercury is a morning star during most of the month but is too close to the sun for favourable observation; on June 25 the planet is in superior conjunction and afterwards becomes an evening star, but sets too soon after the sun—forty minutes on June 30—to be observed. Venus, an evening star, sets at 23h. 20m., 23h. 05m. and 22h. 30m. on June 1, 15 and 30, respectively, and is a conspicuous object in the western sky. The planet reaches its greatest elongation east on June 25, and the visible portion of the illuminated disk varies between 0·62 and 0·45 during the month. Mars is too close to the sun to be observed. Jupiter is a morning star, rising at 1hr. 45m., 0h. 55m. and 0h. on June 1, 15 and 30, respectively. Saturn, an evening star, sets at 1h. 30m., 0h. 35m. and 23h. 35m. at the beginning, middle and end of the month, respectively, and can be seen for a few hours during the night between β and η Virginis. Occultations of stars brighter than magnitude 6 are as follows: June 23d. 02h. 43·7m., γ Capr. (*D*); June 25d. 01h. 11·3m., 96 Aqar. (*R*). *D* and *R* refer to disappearance and reappearance, respectively, and observations from Greenwich are assumed. Summer solstice occurs on June 22d. 05h.

Announcements

H.R.H. THE DUKE OF GLOUCESTER will open the new laboratories of the Tin Research Institute at Fraser Road, Greenford, Middlesex, on May 31.

THROUGH the generosity of Mrs. Armstrong, widow of the late Dr. E. F. Armstrong (president of the Royal Society of Arts and chairman of the Council during 1943–45), and of his son Mr. Richard Armstrong, an endowment has been made for the provision of biennial memorial lectures, to be delivered to the Society on the subject of food. It is hoped that it will be possible to arrange for the first Armstrong memorial lecture to be delivered in the next session of meetings.

A COLLOQUIUM on the "Chemotherapy of Tuberculosis", organized by the Medical Research Council of Ireland, will be held in Trinity College, Dublin, during July 10–13. Further details can be obtained from the honorary secretary of the colloquium, J. G. Belton, at the Laboratories of the Medical Research Council, Trinity College, Dublin.

A SPECIAL discussion meeting of the Royal Anthropological Institute will be held on May 30 to consider "Physical Aspects of Race". The speakers will include Prof. J. B. S. Haldane, Dr. A. E. Mourant, Dr. J. C. Trevor and Prof. S. Zuckerman, who have recently been appointed members of an expert panel of the United Nations Educational, Scientific and Cultural Organization which is to meet in Paris during June 4–8 to consider this subject.

AN ophthalmic optical trade exhibition, organized by the Association of Wholesale and Manufacturing Opticians (secretary: B. G. Arthur, 69 Cannon Street, London, E.C.4), will be held in the two large halls of the Royal Horticultural Society at Vincent Square, London, S.W.1, during July 16–20. About a hundred firms will be exhibiting their products. Prior to the exhibition, during July 10–13, the British Optical Association is sponsoring an international ophthalmic optical congress at King's College, London.

THE fourth annual conference on the "Education of the Young Worker", organized by the Department of Education, University of Oxford, will be held at Manchester College, Oxford, during July 7–13. The aim of the conference is to bring together representatives of industry, education and administration to consider the facilities that already exist for the training of young people, what better use might be made of them, and what should be the ideal programme for the future. The programme can be obtained from the Director, University Department of Education, 15 Norham Gardens, Oxford.

A SERIES of Festival symposia, organized jointly by the Royal Society of Medicine and the British Medical Association, will be held during June at 1 Wimpole Street, London, W.1. The symposia will be open to all members of the medical profession, British and foreign. Some of the topics to be discussed are as follows: the peripheral nervous system (June 4, 2.15 p.m.); antibiotics (June 7, 2.15 p.m.); ophthalmology (June 11, 2.30 p.m.); the central nervous system (June 14, 2 p.m.); experimental endocrinology (June 20, 2.15 p.m.); nutrition and B vitamins (June 21, 10 a.m.); cortisone and A.C.T.H. (June 25, 10 a.m.); physiology of the vascular system (June 25, 4 p.m.); tropical medicine (June 26, 4.30 p.m.); epidemiology (June 27, 4.30 p.m.). Tickets can be obtained from the joint secretary of symposia at B.M.A. House, Tavistock Square, London, W.C.1, and application forms from the May 4 issue of the *British Medical Journal* should be used, if possible.

THE Historical Association will be holding its seventh vacation school for revision courses in history in Thwaite Hall (University College of Hull), Cottingham, East Yorks, during August 2–13. The school is for graduate history teachers and others who are interested, and each member will choose to study within one of seven seminars, there being a tutor and about twelve students in each seminar. One of the seminars is on the "History of Science in the Seventeenth and Eighteenth Centuries", with A. R. Hall, assistant lecturer in the history of science in the University of Cambridge, as tutor. The fee for the course, exclusive of accommodation, is £5 (£4 10s. to members of the Association). Registration forms, to be completed by May 31, and further details can be obtained from the director of the school, F. W. Brooks, 14 Wellesley Avenue, Hull.

ASLIB is preparing a central index of translations, which will include scientific papers, reports and published articles appearing in foreign journals, and which when complete is intended to provide a guide to all translations held in Great Britain and the Commonwealth. A limited number of translations has already been indexed, and inquiries concerning them are dealt with free of charge. To ensure that the index will be complete the co-operation of persons and organizations holding translations is requested. All communications should be addressed to Aslib, 4 Palace Gate, London, W.8.

GEL-LIKE BEHAVIOUR OF DEOXYRIBONUCLEIC ACID SOLUTIONS

By Dr. J. A. V. BUTLER and D. W. F. JAMES
Chester Beatty Research Institute, London, S.W.3

IN the course of experiments on the molecular weight of deoxyribonucleic acid, we have noticed that in aqueous solutions it diffuses in a very unusual manner. Instead of the boundary between the solution and the solvent becoming more and more diffuse, while remaining in the same position, as is the case with more normal substances, it was found that the whole boundary moved forward into the solvent, its front edge remaining very sharp for a considerable time. This behaviour is most marked in aqueous solutions without added salts; but it persists to some extent even with moderate salt concentrations. Fig. 1 shows *Schlieren* pictures of boundaries during diffusion under the conditions stated. The interpretation of these pictures, as in the case shown in Fig. 2, is of a sharp front edge moving into the solvent, with a gradual rise of concentration extending into the solution behind it for a distance which increases with time, until the full concentration of the solution is attained. As the diffusion proceeds, the height of the front edge diminishes.

The distance moved by the edge is proportional to $\sqrt{t}$, as can be seen from a typical example given in Fig. 3. This relation is similar to that recently given for the two-dimensional swelling of gels by C. Robinson[1]. The rate of swelling, as given by the slope of this line, varies linearly with the concentration of nucleic acid. The rate of movement of the boundary diminishes rapidly with increasing salt concentration and in 0·2 *N* salt solutions is scarcely perceptible. But the *Schlieren* diagram remains asymmetric during the diffusion, the edge of the solvent side being much sharper than the other. If the asymmetry of the boundary were due to increase of the diffusion coefficient with decreasing concentration (which is the relation actually observed), it would be expected that the boundary would be more diffuse on the solvent than on the solution side; that is, the molecules would move more rapidly as they get away from each other. The reverse of this is the case, even in salt solutions. It appears, then, that the molecules at the front of the boundary are held back, as they will be if they are united to those behind in some sort of network.

It is well known[2] that, in sedimentation and in electrophoresis, nucleic acid solutions give an exceedingly sharp boundary. This has been ascribed to the self-sharpening property of a boundary when the sedimentation-rate (or mobility) increases with decrease of concentration. It is doubtful if this effect is sufficiently great to give boundaries of the sharpness observed; but they are easily explained if the solutions contain a structural network. The existence of a gel network also explains the high structural viscosity of nucleic acid solutions and their streaming birefringence at very low rates of shear.

To sum up, two types of effects have been observed. In the absence of salt or in the presence of small concentrations of salt (0·05 *N*), a marked 'swelling' of the nucleic acid solution is observed. At greater salt concentrations such 'imbibition' is inappreciable; but the asymmetry of the diffusing boundary remains. It has long been known that the viscosity of nucleic acid solutions is greatly affected by small concentrations of salts. Jordan has suggested[3] that this effect is due to the addition of electrolyte reducing the mutual repulsion of the charged groups of the polymeric ion of nucleic acid, permitting the molecule to coil, thereby giving a more symmetrical structure.

If, as we have suggested, the nucleic acid forms a gel network, even in dilute solutions, we should ascribe the 'swelling' in the absence of appreciable salt concentration to the mutual repulsion of the charges, which will cause the gel to expand. When the charged groups are locally neutralized by added ions, the tendency to expand no longer exists; but the gel network will still be present and will give rise to the anomalous boundary which is observed. On this view the drop of viscosity produced by salts would be due to the salt-free nucleic acid being a 'stiff' gel owing to the mutual repulsion of its parts; while, when these charges are neutralized, the gel will be less stiff and its effect on the viscosity will be less. The continued existence of the gel network in salt solutions will explain why the abnormal structural viscosity is still exhibited by them, though at a lower level.

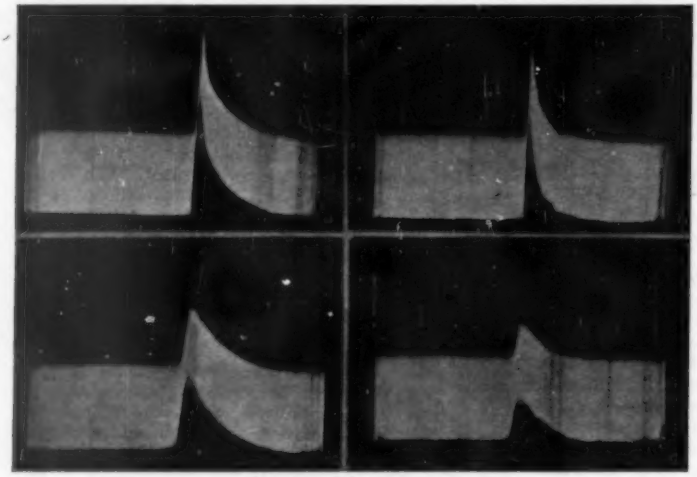

Fig. 1. *Schlieren* photographs of thymonucleic acid boundaries during diffusion

(*a*) 0·4 per cent thymonucleic acid in water after 5·5 hr.; (*b*) 0·2 per cent thymonucleic acid in water after 3 hr.; (*c*) 0·4 per cent thymonucleic acid in 0·001 *N* sodium chloride after 54·5 hr.; (*d*) 0·2 per cent thymonucleic acid in 0·001 *N* sodium chloride after 47·7 hr.

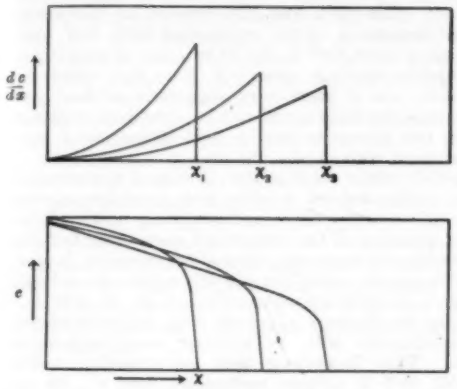

Fig. 2. Interpretation of *Schlieren* photographs, showing nature and position of boundary at different times

On account of the anomalous diffusion pattern the values of the diffusion coefficient which have been recorded[4] must be regarded as very uncertain. It might be expected, it is true, that the elements of gel network, as well as other types of interaction, will be reduced to insignificant proportions by dilution and that the molecular weights of nucleic acid determined from extrapolation to zero concentration will be free from uncertainty on this account. In practice, however, a considerable amount of 'structure' remains in the most dilute solutions with which *Schlieren* pictures can be obtained, and the extrapolations are uncertain. The molecular weights so far obtained are thus of uncertain significance.

It may be noted that it has been shown[5] that, when nucleic acid is treated with various reactive chemicals such as the nitrogen 'mustard' dichlorethylmethylamine, it loses the structural viscosity and gives rise to comparatively normal *Schlieren* patterns in centrifugation and in diffusion[7]. The chief chemical changes produced by this and similar reagents appear to be the alkylation of the groups which are responsible for the formation of hydrogen bonds[6] by means of which the individual chain-like molecules are joined together to form a network. It therefore appears to be likely that the molecular weight of nucleic acid treated with these reagents is more representative of the size of the actual unassociated nucleic acid molecule. Various values in the region of 10^4–10^5

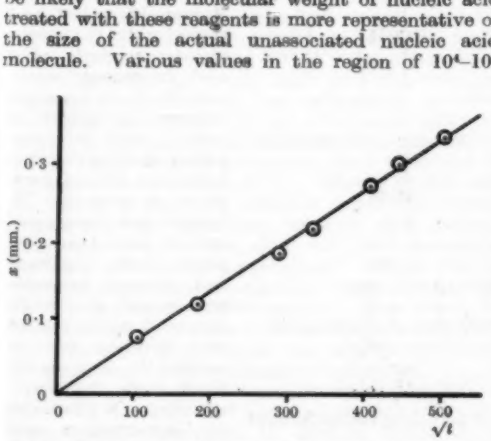

Fig. 3. Position of boundary (x) plotted against $\sqrt{t}$ (where t is time in sec.).

have been obtained[7] for nucleic acid treated with dichlorethylmethylamine.

A fuller account of this work will be published elsewhere.

This investigation has been supported by grants made to the Royal Cancer Hospital by the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the Division of Research Grants of the U.S. Public Health Service. [Jan. 5.

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N-SUBSTITUTED *ISO*GLUCOSAMINE RELEASED FROM MUCOPROTEINS BY THE INFLUENZA VIRUS ENZYME

By Dr. A. GOTTSCHALK

Walter and Eliza Hall Institute of Medical Research, Melbourne

INFLUENZA virus is selectively adsorbed to, and afterwards is eluted spontaneously from, erythrocytes and infectible tissue cells[1]; certain mucoproteins by competing for the virus inhibit its adsorption to red cells, a property lost by previous incubation of the inhibitor with active virus[2]. From these observations on the biological level, the concept evolved that the action of virus on cells is associated with an enzyme embedded in the surface of the infective particle[3]. Because of the wide implications of such a concept, it seemed desirable to provide chemical evidence for the activity of the viral enzyme by isolating and identifying the product(s) of virus-substrate interaction.

As the first result of an investigation directed towards this end, it was reported that the enzyme of influenza *A* virus liberates from ovomucin a carbohydrate – peptide compound[4]. The nitrogenous compound which had reducing power and gave a positive Molisch test exhibited an unusual feature: when treated with alkali (0·1 *N* sodium carbonate, 12 min., 100° C.) it became coupled with *p*-dimethylaminobenzaldehyde to give a purple colour identical with, though much more stable than, that produced by N-acetyl D-glucosamine (I); spectroscopic examination disclosed identity of the bands given by the colouring matter with those of N-acetylglucosamine and the compound respectively known as the auxochrome in the Morgan–Elson test[5]. However, in contrast to the behaviour of N-acetylglucosamine, the compound was stable to prolonged alkaline treatment (30 min. at 100° C.) as tested by colour formation with *p*-dimethylaminobenzaldehyde and by its reducing power, and it was most sensitive to mineral and organic acids. After heating for several hours with 1 *N* hydrochloric acid the reducing power of the compound decreased and it failed to give a colour with *p*-dimethylaminobenzaldehyde, even

after appropriate pretreatment with acetylacetone, whereas glucosamine arising from the acid hydrolysis of N-acetylglucosamine is known to withstand 6 *N* hydrochloric acid without loss of its ability to produce a characteristic red colour with acetylacetone and *p*-dimethylaminobenzaldehyde. Instead, the acid treatment of the compound resulted almost immediately in dark brown coloration and formation of considerable amounts of black insoluble humin.

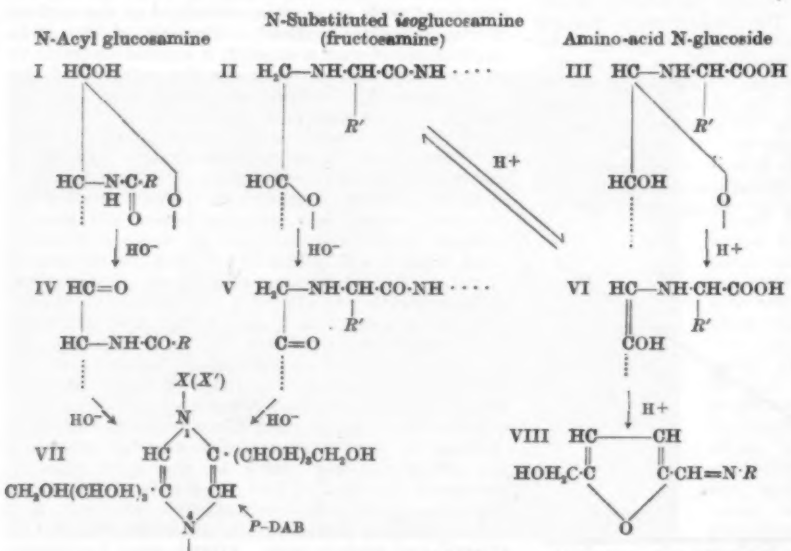
Investigation of the properties of the purified ovomucin proved this preparation to be a protein fraction consisting of at least two mucoproteins, the specific substrate for the viral enzyme contributing not more than 5–10 per cent to the total fraction[6,7]. We took advantage, therefore, of a procedure described by Tamm and Horsfall[8] to obtain from human urine a mucoprotein (12·2 per cent nitrogen) acting as inhibitor of virus hæmagglutination. A slight modification of the method provided an electrophoretically homogeneous product[9].

Highly purified influenza *B* virus (*LEE*) containing 100,000 agglutinating doses (against 1 per cent fowl red cells) per mgm. nitrogen[10] was allowed to act on a 0·3 per cent solution of the urine mucoprotein at 37° C. for 3 hr.; the mixture was then dialysed against distilled water and the dialysate concentrated *in vacuo* to dryness; appropriate controls were treated accordingly. By this procedure, followed in part of the experiments by adsorption on to and elution (0·1 *N* acetic acid) from calcium oxalate, a carbohydrate-containing compound was obtained from the dialysate of the mucoprotein-virus assay in a yield of about 1 per cent of the substrate used.

The compound gave a positive Molisch test and reduced ferricyanide and *o*-dinitrobenzene (in alkali). Its examination by paper chromatography with butanol/acetic acid as solvent revealed a ninhydrin-reacting spot of $R_F = 0{\cdot}03$, very similar to that given by L-lysine N-glucoside described previously[11] and most probably due to the presence of combined lysine; this spot was not present in the control. After treatment of the compound with 6 *N* hydrochloric acid at 100° C. for 24 hr., one or possibly two ninhydrin-reacting spots of low R_F value were located, one of them very suggestive of free lysine. The carbohydrate could not be detached unchanged from the amino-acid(s) by acid hydrolysis; again, treatment with dilute acid (0·1 *N* hydrochloric acid or 0·5 *N* oxalic acid) at 100° C. turned the compound into dark-coloured soluble and insoluble material, coincident with a decrease in reducing power. Whereas a quantity of the compound containing 0·2 mgm. reducing substance (as glucose) gave a stable, intensely purple colour in the Morgan–Elson test, upon heating with 1 *N* hydrochloric acid for 5 hr. at 100° C. its ability to produce a colour with *p*-dimethylaminobenzaldehyde with or without acetylacetone was lost. This behaviour and its stability towards alkali (0·1 *N* sodium carbonate, 100° C., 30 min.) excluded *N*-acyl-hexosamine as a component of the compound.

A similar sensitivity towards mild acid treatment was observed with amino-acid N-glucosides (III) prepared from their components at 37° C., as described previously[11], or in a pure state and better yield by refluxing the aldohexose and amino-acid in dry methanol for 8–10 hr. DL-Phenylalanine N-glucoside when treated with 0·5 *N* oxalic acid or 0·01 *N* hydrochloric acid turned black within 3 hr.; the chromatogram showed free phenylalanine, 5-hydroxymethylfurfural, a small amount of unchanged N-glucoside, but no free glucose. In their reaction towards alkali, however, the secondary N-glycosides differed from the compound. When heated at *p*H 9·0 for 12 min. at 100° C., phenylalanine N-mannoside decomposed with liberation of the amino-acid. Furthermore, the pure amino-acid N-glycosides did not form a colour in the Morgan–Elson test; it was only after heating with acetylacetone in alkali that a reddish colour similar to that of a D-glucosamine standard was formed on addition of *p*-dimethylaminobenzaldehyde.

Since the compound split off from mucoprotein closely imitated I in the colour of the Morgan–Elson test, and shared with III the sensitivity towards mild acid treatment, structure II—in its principal features an isomer of both I and III—suggested itself as the configuration of the compound in question. N-Substituted *iso*glucosamines have been prepared from D-glucose and primary aromatic amines such as *p*-toluidine and α-phenetidine with hydrogen ions as catalyst[12]; they are derived from the corresponding N-glucosides by isomerization and are essentially I-substituted ketoses, as evi-

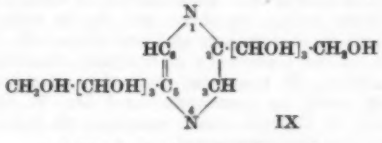


1,4-Disubstituted dihydropyrazine derivative ($X = —CO·R$; $X' = —CHR'·CO·NH · · ·$)

Schiff's base of 5-hydroxymethylfurfural

denced by the positive colour reactions for ketoses, their ability to form oximes and the failure to detach glucose by acid treatment. Our compound was found, too, to give the colour tests for fructose (Seliwanoff, Tashiro and Tietz), and not to release its sugar moiety upon acid treatment.

It may be mentioned that *p*-tolyl *iso*-D-glucosamine undergoes humin formation even more readily than does *p*-toluidine N-glucoside. Apparently the tautomeric mobility of the vinylamine structure VI formed under acid conditions from both II and III greatly facilitates the formation of the Schiff's base of 5-hydroxymethylfurfural (VIII), an intermediate in the production of the latter and most probably of humin[11]. In the acid-resistant glucosamine the amino-group is attached to C_2 and displaces there the hydroxyl essential in the process of sugar dehydration by acid.



IX

2,5-Di-tetrahydroxybutylpyrazine

The common feature of the N-substituted amino-sugars glucosamine (I) and fructosamine (II) is the presence in them of the potential α-amino carbonyl grouping (IV, V) which would seem to be a prerequisite for the positive Morgan–Elson test. Since α-amino-ketones and aldehydes of the types *R*.CO.$CH_2.NH_2$ and CHO.CH*R*.NH_2 respectively readily self-condense to the dihydropyrazine derivative and in turn are oxidized to the corresponding pyrazine, it may be assumed that glucosamine and fructosamine are transformed by alkali treatment into the same pyrazine derivative, 2,5-di-tetrahydroxybutylpyrazine (IX); indeed, ammonia-treated fructose has been shown[12] to undergo condensation and oxidation to IX. Obviously the N-substituted amino-sugars I and II can form only the N-substituted dihydropyrazine derivative VII. Structure VII with two active hydrogens to react with *p*-dimethylaminobenzaldehyde would account[14] for the colour formation in the Morgan–Elson test. VII with *X* as substituent (cf. diagram) may be expected to give an unstable colour with *p*-dimethylaminobenzaldehyde, since under the impact of the acid present (mixture of glacial acetic and hydrochloric acid at 20° C.) the amide bond >N—CO.*R* will be slowly split and the resulting compound oxidized to the resonating pyrazine derivative IX, which is devoid of an active hydrogen atom. On the other hand, VII with *X'* as substituent will be stable both to prolonged alkali treatment in the heat and to acid at 20° C., because in this case the link is of the >N—CH.*R.R'* type. The weakly positive Morgan–Elson test observed with purified amino-acid N-glycosides after mild acid treatment and with our earlier preparations[11] results from a transient Amadori rearrangement to the corresponding N-substituted *iso*glucosamine; this could be demonstrated by the observation that subsequent to this treatment they acquire the ability to reduce instantaneously *o*-dinitrobenzene in the cold.

On the evidence presented, it seems justified to ascribe to the compound liberated enzymatically the *iso*glucosamine structure II, and to define it as N-1-deoxy-1-ketose amino-acid (or peptide). The presence of the sugar is shown by the Molisch test, its keto configuration by the Seliwanoff test and the existence of a free reducing group by the reduction of ferricyanide and *o*-dinitrobenzene. The positive Morgan–Elson test is indicative of a substituted amino-group in the α-position to the reducing group (N-substituted amino-sugar), and the stability to acid and alkali of the bond linking the substituent with the amino-group demonstrates that the amino-group is not associated with a carbonyl-group. Finally, the ready transformation by mild acid treatment of the compound into humin material may be taken as additional evidence for the attachment of the amino-group to C_1 of the sugar. The result of the chromatographic analysis suggests that an amino-acid or peptide is an integral part of the compound.

In conclusion, it may be appropriate to consider the bearing of the findings reported above on our knowledge of the mode of linkage between nitrogenous matter and carbohydrate in natural compounds. There would appear to be two distinct types: (1) in nucleosides the base molecule derived from pyrimidine or purine is in glycosidic linkage with the pentose and therefore detachable by acid hydrolysis; (2) in amino-sugars the base is bound to the carbon atom vicinal in the reducing group; in the N-substituted 1-amino-1-deoxy ketose, described here, the amino-group is shared between the amino-sugar and an amino-acid, thus moulding the carbohydrate and amino-acid into a compact unit from which the sugar moiety cannot be recovered by simple hydrolysis. This type of linkage between a carbohydrate and amino-acid may well represent a general pattern according to which, in mucoproteins, the poly- or oligo-saccharide is joined to its protein partner.

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TEXTURE AND STRUCTURE OF METALS

THE spring meeting of the X-Ray Analysis Group of the Institute of Physics was held at Ashorne Hill during April 12–13, the papers presented dealing with metals. Since a detailed report of the conference is to appear elsewhere, this present article is concerned only with general tendencies as they appeared to one particular member; omission of reference to any contribution should therefore be taken only to mean that this contribution was difficult to classify and not that it was necessarily unimportant. For obvious reasons, the author has not found it possible to include a summary of the evening lecture given by Prof. N. F. Mott, as this would require an article to itself.

Technical Advances

Perhaps the most outstanding impression produced by the various papers is the number of advances in technique, which now allow the solution of problems which were until recently only on the fringe of possibility; no single obvious step forward can be noted, but by attention to detail and the use of analytical methods, results which were formerly qualitative can now be assessed quantitatively, with a corresponding increase in their significance.

As an example, the work of Dr. R. A. Smith, of the University of Birmingham, may be quoted. Fourier methods[1,2] have been applied to the analysis of the line shapes given by martensite and iron–nickel alloys, and the results show that the cause of the broadening is mainly the presence of internal stresses. On a coarser scale, Dr. G. B. Greenough, of the Royal Aircraft Establishment, described investigations of the residual strains and stresses that are present in plastically deformed material; he emphasized that the X-ray method is unique in that it selects grains of particular orientation, and care should therefore be taken in comparing results with those obtained from macroscopic testing methods.

Preferred orientation in cold-worked metals was also discussed at some length. Although a mass of information is now available, no general theory of its occurrence is yet accepted, and there is little basis for predicting the deformation texture of any particular alloy. Starting from the known behaviour of single crystals under stress, E. A. Calnan and Dr. C. J. B. Clews, of the National Physical Laboratory, showed that the texture of several cubic and hexagonal metals can be accounted for. This approach, however, is still essentially empirical and a theory of the deformation of single crystals is still awaited.

Dr. T. L. Richards, of I.C.I. (Metals), Birmingham, discussed the behaviour of metals under very heavy deformations, and Mme. A. R. Weill gave an example of the practical importance of these studies; she showed how the junction of oriented and unoriented material could be a place of weakness in metallic bodies.

Development of Experimental Methods

Progress has not been solely in the improvement of standard methods; much thought has also been given to the development of new methods, a particularly instructive example being given by Dr. R. W. K. Honeycombe, of the Cavendish Laboratory, Cambridge. He showed some impressive photographs of single crystals taken by X-ray microscopy[3,4] with magnifications up to about 100; the method promises to be very useful for examining deformed metal crystals.

At the other end of the scale, experiments are also being carried out at the Cavendish Laboratory to extract as much information as possible from polycrystalline material; Mr. P. Gay described how beams less than 20 μ in diameter are being used for exploring small groups of crystal grains. These methods demand considerable experimental skill, and should soon be adding greatly to our knowledge of metals in the polycrystalline state.

The long exposures required for X-ray photographs make the ordinary X-ray method useless for following rapid transformations such as those that occur in steels at elevated temperatures. This difficulty can be removed by the use of Geiger counters, and Mr. H. T. Heal and Mr. H. Mykura described their arrangement; they measured the intensities of separate lines given by austenite and ferrite, and were able to find quantitatively how the proportions of the two changed with time at any particular temperature. This method should bring a host of new problems within the province of X-ray diffraction.

Another noteworthy point which emerged from the conference was the way in which X-ray methods are finding their place in the general scheme of metallurgical investigation. About 1930, metallurgists were wont to accuse X-ray diffractionists of appearing to believe that the new method would displace existing methods. This charge can certainly not be made now; in some of the papers the use of X-rays merely as an ancillary to other methods were described, and in many others the importance of the correlation of several methods was emphasized.

For example, Mr. R. J. Davis, of Oxford, described a detailed microscopic examination of an α/β brass, his results being supplemented by a microbeam investigation undertaken at Cambridge. Mr. D. V. Wilson, of the University of Sheffield, described the examination, by magnetic methods[5], of the effects of cold work on cementite, and Dr. W. Hume-Rothery, of Oxford, made reference to the use of specific-heat measurements[6].

Perhaps the most intriguing results were provided by Dr. J. F. Brown, of I.C.I. (Billingham), who showed electron diffraction photographs of single crystals of metals. There appears to be a wealth of information in such photographs, and they provide a way of examining single crystals which are too small for X-ray examination. Exposure times are of the order of seconds, and, in fact, patterns can be observed visually on a fluorescent screen.

Structure Determination

Of the examples of structure determination mentioned, by far the most prominent was that of the sigma-phase of the iron–chromium system; this phase, when it appears in stainless steels, has deleterious properties, and 'asigmatic' alloys are greatly to be desired. Understanding of the nature of the formation of the phase depends upon knowledge of its structure, and Dr. A. M. B. Douglas, of the Cavendish Laboratory, showed how this had been determined.

Powder photographs proved to be too difficult to interpret, and the unit cell was determined only from the data provided by electrolytically extracted single crystals. This unit cell appeared to be similar to that found by Tucker[7] for β-uranium, and calculation showed that the structures of the two substances were indeed similar. Thus, after several years of investigation, the determination of the atomic arrangement appeared somewhat as an anti-climax.

Dr. J. Thewlis, of the Atomic Energy Research Establishment, Harwell, also discussed the structure of uranium; he emphasized the difficulty of interpretation of powder photographs, and stated that systematic methods, such as that of Ito[8], could be misleading.

Another interesting structure is that of Mn_3SiAl_9, reported by Dr. K. Robinson, of the Cavendish Laboratory; this is similar to Co_2Al_5[9], except that some of the aluminium sites are vacant. Dr. Robinson suggested that this phenomenon is due to the higher electron concentration caused by the addition of silicon. Comparison of structures in this way may well lead to a greater understanding of the metallic state, along the lines of the now-famous Hume-

Rothery rule. The importance of structure determination was stressed by Prof. G. V. Raynor, of the University of Birmingham, who made a plea for more structure results to help the theoretician.

That complete structure determination is not always necessary was shown by Dr. Hume-Rothery, who discussed the γ-copper–gallium phases; as excess of gallium is added, related structures are formed, and, although the atomic positions have not been determined, it is evident from density measurements that the number of atoms in equivalent unit cells decreases. This behaviour, which is exactly similar to that of copper–aluminium alloys, appears to be caused by attempts to maintain a constant value for the number of electrons per unit cell[10]; this concept may well prove more fruitful than the number of electrons per atom in accounting for structures with vacant sites, such as Mn_2SiAl_2.

Mr. H. J. Goldschmidt, of the B.S.A. Group Research Centre, Sheffield, gave a practical bias to this session of the conference. He showed how structural considerations provide a basis for the classification of carbides, and described, with a wealth of detail, how it is possible to predict which carbides will be present in a steel of given composition.

Structural Perturbations

Not all structures are perfect, and the diffraction effects given by certain imperfect structures provide fascinating material for study. Perhaps the best known of these defects is that which occurs in cobalt[11], and an attempt at a theoretical explanation of the structure was given by Dr. J. W. Christian, of Oxford. He described the transformation from cubic to hexagonal cobalt as martensitic in nature—that is, occurring by glides of planes of atoms over each other. No purely mechanistic description, however, can be said to 'explain' the faults; energy considerations must be the final arbiter, and Dr. Christian made no attempts to deal with these.

Dr. K. H. Jack, of the University of Durham, described how, in carbon and nitrogen martensites, precipitation of a new phase, such as cementite, may start as platelets only a few unit cells thick, so that one of the Laue conditions for X-ray reflexion is relaxed. He described the effect of this phenomenon on X-ray powder photographs. Platelets of this type seem to provide a favoured mode of precipitation, as shown by the classical work of Preston[12] and Guinier[13] on age-hardening aluminium alloys. Dr. A. Taylor, of the Mond Nickel Co., Birmingham, also discussed the martensite structure, and compared the development of this tetragonal structure to that occurring in the copper–manganese system; here the axial ratio changes abruptly from unity and thus he saw no reason why cubic martensite should not occur at low carbon concentrations.

Dr. J. B. Newkirk, of the Cavendish Laboratory, described the diffraction effects given by single crystals of the alloy CoPt; streaks pass through the X-ray reflexions, and these again probably represent the incipient formation of platelets. An experimental approach to the study of such phenomena was described by Dr. H. Lipson, of the Manchester College of Technology; he described how diffraction gratings of 1 mm. spacing were made with different degrees of short-range order, and how the diffraction patterns in visible light[14] could be compared with X-ray diffraction patterns. Although only two-dimensional, the method had been used with some success to account for the diffraction effects from $AuCu_3$[15], and Dr. Lipson showed a ciné film which demonstrated the growth of superlattice lines from the background of a diffraction photograph.

That such studies are not only of academic interest was shown by Mr. T. R. Pomeroy, of the British Non-Ferrous Metals Research Association. He described how the corrosion properties of iron–nickel–copper alloys were found to depend upon the development of a periodic structure before dissociation[16], and explained how this structure had been detected by means of the electron microscope.

From all these results, and many others which were mentioned in discussion, it was evident that the subject is developing along very healthy lines; theoretical and practical academic work are proceeding in parallel with technical applications, each being dependent upon and invigorating the others. Considerable progress may be expected in the next ten years in our understanding of the metallic state, which at present provides so many persistent but fascinating problems.

H. LIPSON

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UNITED STATES NATIONAL ACADEMY OF SCIENCES

AT the annual general meeting of the United States National Academy of Sciences, held in Washington, D.C., during April 23–25, the following officers, new members and foreign associates were elected.

Home Secretary: A. Wetmore, at present secretary of the Smithsonian Institution, for a four-year term, in succession to Dr. F. E. Wright, formerly of the Carnegie Institution of Washington, who has been home secretary of the Academy for the past twenty years.

New Members of Council: J. W. Beams, chairman of the School of Physics, University of Virginia; and E. C. Stakman, chief of the Division of Plant Pathology and Botany, University of Minnesota.

New Members: W. C. Allee, head of the Department of Biology, University of Florida; N. E. Bradbury, director of Los Alamos Scientific Laboratory, Los Alamos, N.M.; D. Brouwer, director of Yale Observatory, New Haven; R. E. Clausen, chairman of the Division of Genetics, University of California; E. DeGolyer, senior partner of DeGolyer and MacNaughton, Dallas; J. T. Edsall, associate professor of biological chemistry, Harvard Medical School; R. M. Fuoss, Sterling professor of chemistry, Yale University; R. Gunn, director of the Division of Physical Research, U.S. Weather Bureau, Washing-

ton, D.C.; H. F. Harlow, chairman of the Department of Psychology, University of Wisconsin; C. O'D. Iselin, senior physical oceanographer, Woods Hole Oceanographic Institution, Woods Hole, Mass.; R. Kellogg, director of the U.S. National Museum, Washington, D.C.; R. H. Kent, associate director of the Ballistic Research Laboratories, Aberdeen Proving Ground, Maryland; D. W. Kerst, professor of physics, University of Illinois; C. C. G. King, director of the Nutrition Foundation, New York; S. K. Lothrop, curator of Andean archæology, Peabody Museum, Harvard University; T. B. Nolan, assistant director of the U.S. Geological Survey, Washington, D.C.; E. M. Purcell, professor of physics, Harvard University; A. J. Riker, professor of plant pathology, University of Wisconsin; H. P. Robertson, professor of mathematical physics, California Institute of Technology (on leave to the Weapons Systems Evaluation Group, Washington, D.C.); F. D. Rossini, chairman of the Department of Chemistry, Carnegie Institute of Technology; A. B. Sabin, professor of research pediatrics, Children's Hospital Research Foundation, Cincinnati; F. Schrader, head of the Department of Zoology, Columbia University; F. Seitz, research professor of physics, University of Illinois; W. Shockley, research physicist at the Bell Telephone Laboratories, Murray Hill, New Jersey; T. G. Thompson, director of the Oceanographic Laboratories, University of Washington; W. S. Tillett, head of the Department of Medicine, New York University College of Medicine; G. T. Whyburn, chairman of the Department of Mathematics, University of Virginia; C. J. Wiggers, professor of physiology, Western Reserve University School of Medicine; W. G. Young, dean of the Division of Physical Science, California Institute of Technology.

Foreign Associates: P. Eskola, professor of geology and mineralogy, Helsinki University; Sir Godfrey Thomson, professor of education, University of Edinburgh; K. von Frisch, director of the Zoological Institute, University of Munich.

CENTRAL ROAD RESEARCH INSTITUTE, INDIA

A CONFERENCE of chief engineers of Indian States and Provinces which assembled at Nagpur at the end of 1943 emphasized the need for a Road Research Institute. The 'Nagpur Report' recommended the construction and improvement of about 400,000 miles of various types of roads; and an efficient and economical execution of such a developmental programme obviously demanded a Road Research Institute. The question was considered by the Council of Scientific and Industrial Research as well as by the Ministry of Transport, and it was decided that the proposed Institute should be part of the chain of national laboratories being planned by the Council. Road research was to be the care of the Council, while development was to be undertaken by the Transport Ministry, the Council and the Ministry working in the closest co-operation. In 1945 the Council appointed a Road Research Planning and Advisory Committee to work out details for the proposed Institute. The Planning Committee saw great advantage in locating the Institute near Delhi, particularly as the main and arterial roads converge on Delhi. Many sites near Delhi were examined. The 32-acre site finally chosen near Okhla on the Delhi–Muttra Road, though only about seven miles from Delhi, is really part of Uttar Pradesh, and has been presented to the Institute by the Bishop of Delhi and Simla.

The governing body of the Council of Scientific and Industrial Research received the Planning Committee's recommendations during 1948. The proposals envisage the setting up of one main field experimental station and a road test-track to carry out experiments on different kinds of road surfaces and to test their behaviour under actual road conditions. The Council is to provide funds for the establishment of the Institute and will be in charge of it, while the field experimental station will be financed and controlled by the Ministry of Transport. Dr. R. K. N. Iyengar had already in the latter half of 1947 been appointed assistant director (planning). Dr. Ernst Zipkes, a Swiss road engineer, formerly in charge of the Department of Road Research in the Federal Institute of Technology at Zurich, was appointed director, and the Research Institute has been functioning under him in a temporary laboratory at Okhla. The foundation stone of the new Institute was laid on September 6, 1950, by the Minister of Transport, the Hon. Mr. N. Gopalaswamy Ayyangar, who explained the scope and possibilities of the Institute and the importance of the work it is expected to do. The Central Institute will, among other things, co-ordinate the work of all local stations, such as those at Madras, Karnal, Lucknow, Patna, Calcutta and Poona.

Sir Shanti Swarup Bhatnagar, director of the Council of Scientific and Industrial Research, gave a brief account of the steps leading up to the establishment of the Institute. He defined its functions thus: (1) fundamental research on the behaviour of materials used in road construction, and devising of methods of measurement for this purpose; (2) correlation of laboratory test results on standard materials with those under actual investigations, in order to enable reliable estimates to be formed of the behaviour of various road materials in practice; (3) tests on soils and a study of soil mechanics for the evolution of low-cost roads; (4) research connected with the standardization of specifications for roads and road-building plant and machinery; (5) devising of instruments for various tests on roads and bridges, such as measurement of the irregularities of road surfaces, impact factors, automatic recording of traffic, etc.; (6) studies on the characteristics of different types of road under different traffic conditions, incidence of accidents, road-safety devices and road statistics; (7) undertaking co-operative research schemes and co-ordination with engineering colleges, other research institutes and industrial concerns doing similar work, and tendering technical advice and assistance when sought; (8) dissemination of results of research and experiments by means of pamphlets, journals and films for the benefit of road engineers.

Special emphasis, Sir Shanti said, would be laid on rural roads and their development "from easily and locally available material in such a manner that they can be constructed with the help of local labour at a very low cost".

Dr. Zipkes, director of the Institute, summing up the tasks of a Road Research Institute, said: "Road research investigates how to construct in a given area the most solid and safest possible road using the

natural and most economical means". As a corollary and an amplification he added: "Highway construction leads its engineers into Nature—Nature under all her aspects. For roads are meant to overcome Nature, but at the same time they should be in harmony with Nature. Above all, roads must essentially be built with the material the surrounding Nature provides. We may add bitumen, tar, cement, but as basic material we have to use the stone, the sand, the earth that lies nearby."

It was no accident, therefore, that the foundation stone itself was not the usual marble slab but a rough quartzite stone dug out of the very site. With a feeling of pride, Dr. Zipkes said: "We dug it out of our own ground, very near this place. And we brought it here for our foundation stone ceremony to be a symbol of what we are going to do inside the walls that will rise around this stone. Use the materials that Nature provides, and search for ways to construct with them the most solid, safest and most economical roads."

PAINTS AND OTHER SURFACE COATINGS

THE results of much new scientific and technological work relating to paints and other surface coatings and printing inks, including new raw materials and equipment, were displayed at the third Technical Trade Exhibition organized by the London Section of the Oil and Colour Chemists' Association and held at the Borough Polytechnic, London, during March 19–21. The number of exhibitors increased from twenty-six in 1950 to thirty-four this year.

The Paint Research Station demonstrated an approach to the prediction of the colour of pigment mixtures, and some applications of radioactive tracers. The radioactive isotope in natural potassium has been used for determining this element in potassium chromes; and pigment sedimentation, flotation, and drier absorption are other problems to be investigated by the new techniques. The mechanism of polymerization will be studied by introducing radioactive carbon into different parts of the molecules of drying oils.

A photoelectric colour meter was shown which has eight colour-filters stopped down so that the same amount of light passes through each; one setting for 100 per cent (with magnesium oxide) then suffices for a series of panels. Another exhibit, a prototype of a reflecting microscope, showed the instrument to be of simple design and very easily adjusted. A system of mirrors projects the image (free from chromatic aberration) on a grey screen, and there is no eye-piece. Modifications under development include the use of downward illumination for examining opaque objects.

Attractive items for the laboratory were an unbreakable aluminium vacuum desiccator with plate-glass inspection window and grease-free sealing joint, and a metal tap for ordinary glass vacuum desiccators. The only vacuum oven made in Great Britain with single-action door closure was also to be seen. A new *Z*-blade mixer that was on show has interchangeable 1-pint and 1-quart pan sections and blades, and a heavy-duty stainless steel mixer in three sizes has a new type of packed gland and can be adapted for working under vacuum.

Further research and development work on isomerized rubber has led to new applications in printing inks and a new floor paint for concrete, an emulsion providing a vehicle for alkali-resistant wall primers, and a copolymer with styrene for use in water-resistant and anti-corrosive paints. A new finely dispersed polyvinyl acetate emulsion was demonstrated to yield more glossy films than older types and to possess better adhesion after immersion in water. Newly developed polyacrylate dispersions were shown in leather finishes. A new technique gives alkyd resin dispersions of smaller particle-size than formerly, suitable for use in industrial paints.

Epichlorhydrin alkyd resin coatings, stoved or air-dried, were seen to resist attack by 70 per cent sulphuric acid and 30 per cent caustic soda, while the remarkable heat resistance of silicone-modified alkyds was exemplified by pigmented finishes stated to have been exposed at 450° C. for 500 hr. and at 300° C. for 1,000 hr., which were without apparent deterioration, except some loss of gloss. Alkyd-melamine resins plasticized with coconut oil were shown to possess enhanced colour retention.

Epichlorhydrin-diphenylolpropane resins, a recently discovered class having only C—C and ether bonds, contain reactive hydroxyl and epoxy groups; their particularly good resistance to strong alkali was demonstrated. They can be used cold-cut with a cross-linking resin (for example, urea or melamine), or esterified with drying-oil fatty acids to give air-drying media.

Many quite new derivatives of sebacic acid were exhibited, including diallyl sebacate recommended as a cross-linking agent for drying oils, polypropylene sebacate as a non-migrating plasticizer, sebacamide as a urea resin modifier, and sebacic polyanhydride as an alkyd intermediate. A series of chlorine-containing plasticizers for cellulose acetate comprises trichlorethylideneglycerol and derivatives. A new 'sequestering' agent, the di-sodium salt of ethylene diamine tetra-acetic acid, can deactivate the ions of various metals, and may be used to prevent 'poisoning', decomposition, etc., caused by traces of metal ions, to stabilize emulsions, to titrate metals, and for many other purposes.

Two new adipates, the dinonyl and di(3,5,5-trimethylhexyl) compounds, were shown as low-temperature plasticizers for cellulose derivatives and resins, and two new phthalate plasticizers for lacquers are the di(2-butoxyethyl) and di(ethylene glycol monobutyl ether) compounds. New high-boiling solvents for non-blushing nitrocellulose lacquer emulsions are octyl acetate (b.p. 198° C.) and nonyl acetate (b.p. 207° C.).

Calcium plumbate is a new, light-coloured pigment for anti-corrosive paints; a pale dull tan, it can be tinted green, light stone, grey or brown. The known anti-corrosive property of zinc dust was related in a demonstration to the electrical conductivity of coatings made with this pigment. Interesting panels showed new work with zinc dust in inorganic media such as sodium silicate; in 'cementiferous' compositions based on barium chloride, potassium dihydrogen phosphate and magnesium chloride; and mixed with zinc oxide in a wood primer. Research on zinc oxide pigments shows that flow and resistance to 'chalking' increase with particle size, while oil absorption falls; under ultra-violet radiation the more reactive particles can be distinguished from the less reactive by the colour of their fluorescence.

NEIL R. FISK

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Asymmetry of Larval *Amphioxus*

The evidence for the theory that *Amphioxus* is "essentially a pædomorphic transformation of a sessile Protascidian" is even stronger to-day than when Garstang[1] first proposed it. The more recent of Conklin's investigations[2] have shown the early development of *Amphioxus* to be "more strikingly like that of Ascidians than has been recognized hitherto", and the fate-map of *Amphioxus* is very closely similar to that of *Ascidiella*[3]. One apparent anomaly—that the egg of *Amphioxus*, unlike the ascidian's, is still of the 'regulation' type after its first cleavage[4]—yields to Berrill's quantitative proof[4] of the relative retardation of the development of *Amphioxus*, and the absence of a larval enterocœle and segmented mesoderm in Ascidians may perhaps do so too. But there remains one notorious obstacle to attempts to bring the two forms more closely into line: the grotesque asymmetry of the *Amphioxus* larva. Half a dozen theories have therefore been devised to explain it away as a larval adaptation of secondary import; but none has been proposed with much conviction or generally agreed upon. The interpretation to be set out here, so far from alienating *Amphioxus* from the ascidian, argues for an even closer affinity between them than is generally admitted.

It is usual to think of the asymmetry of the pre-metamorphic embryo of *Amphioxus* in terms of the positions which the mouth and pharyngeal organs come to acquire in the adult; but for some purposes it is more revealing to think of it in relation to the disposition of the endopharyngeal apparatus in the ascidian tadpole. In the typical fully developed ascidian tadpole, the mouth is dorsal and the pharyngeal axis lies at right angles to the axis of the notochord. The presumptive posterior wall of the pharynx is therefore ventral and the presumptive mid-ventral line, with the endostyle, anterior. It may be said, following Willey closely[5], that the lay-out of the endopharyngeal apparatus of the larva of *Amphioxus* is about as close to that of the ascidian larva as the forward extension of the notochord allows. The mouth cannot be dorsal, but it is lateral or dorso-lateral; the endostyle, though of necessity lying somewhat obliquely, is more nearly vertical than horizontal and is still the most anterior endodermal organ of the body[5]. Garstang[1] would have none of this interpretation, because it rested "on the impossible assumption that the dorsal position of the mouth in ascidian larvæ is primitive"; but that, in its turn, rests upon the acceptance of a much more distant affinity between ascidians and *Amphioxus* than modern evidence requires.

What is the phylogenetic history of the complex morphogenetic movement, in consequence of which the presumptive mid-ventral line of *Amphioxus* comes to assume its adult position and the mouth becomes an anterior aperture lying ventral to the axis of the notochord? The suggestion to be made here is that this movement is homologous with the complex rotation of the endopharyngeal apparatus which the ascidian tadpole undergoes in anticipation of sessile life. (An analogous shift in the relative position of the mouth occurs during the metamorphosis of the motile larvæ of other sessile invertebrates; for example, among crinoids, Polyzoa Endoprocta and cirripedes.) The two processes are not easy to compare, for one refers the metamorphic torsion of *Amphioxus* to the axis defined by the notochord, and that of the ascidian to its point of fixation; and the second comparison is obscured by the involution of the larval notochord and nervous system that accompanies metamorphosis. Nevertheless, the outcome of the torsion process in ascidians is to cause the endostyle to take up an anatomically mid-ventral position and the mouth to lie anteriorly and ventrally. The larval torsions of *Amphioxus* and ascidians have, therefore, the same anatomical outcome, though the ways in which it is achieved are a little different, as the persistence and forward extension of the notochord in *Amphioxus* might well require.

The natural or artificially induced delay of tail resorption in some ascidian tadpoles strengthens this interpretation, for it is a 'natural experiment' which answers the question: 'What would be the final disposition of the endopharyngeal apparatus in ascidian larvæ if fixation and metamorphosis were pædomorphically excised?' The larva of *Distaplia* figured by Berrill[6], still free-swimming at a stage when it should normally be sessile, shows the notochordal axis, mouth, endostyle, pharynx and gut arranged in the pattern which they come to acquire in *Amphioxus* after metamorphosis is complete. The behaviour of larval *Amphioxus* is also most revealing. Over the period during which, if it were indeed an ascidian, it should attach itself to the substratum and undergo metamorphosis, *Amphioxus* stops growing in length, deserts the surface waters, and becomes immobile or relatively inactive; it may also, as Orton first showed[7], attach itself to the substratum on its front end. The organs by means of which it does so, if van Wijhe is to be believed[8], are cutaneous sticky-secretion glands homologous with the adhesive papillæ of ascidian tadpoles. (The glands disappear at metamorphosis.) It is very hard to believe that this rather exact correspondence of behaviour is no more than a gratuitous coincidence. If Willey's proposal is accepted—that the larvæ of the organisms ancestral to *Amphioxus* had dorsal mouths and anterior endostyles—then it follows naturally that metamorphosis of *Amphioxus* and the behaviour associated with it is a phylogenetically transformed variant of the metamorphosis of ascidians.

In the light of this interpretation, Garstang's theory of the origin of *Amphioxus* from ascidians needs a small qualification. It is perhaps not quite right to say that *Amphioxus* is a pædomorphic *prot*ascidian. It is a pædomorphic transformation of an ascidian of perhaps great geological antiquity but of relatively up-to-date pattern—one in which the endopharyngeal apparatus belonging ancestrally and functionally to the sessile adult stage appears precociously in the larva. The big sack-like pharynx perforated by gill slits, the mucus-secreting endostyle, the ciliary feeding-current, the atrium, etc., are physiologically appropriate to a *sessile* animal, the adult tunicate. The occurrence of these structures in the larva (in which they are functionless: the larva does not feed) is a secondary acquisition, an anticipation in the embryo of adult structures[9]. It is from a larva of this type that *Amphioxus* must have been derived, by an almost but not quite complete suppression of fixation and the routine of

behaviour with it, and the complete elimination of the tunicate adult stage. *Amphioxus* thus contrives to combine the endopharyngeal apparatus of the adult ascidian (which it continues to make use of in an almost exactly ascidian-like way[10]) with the notochord, tail, nervous system, etc., of the larva. There seems no reason at all why this sort of thing should not have happened more than once—the Larvacea are evidence that it happened twice—or why it should not begin to happen again to-day or to-morrow. It may therefore be that the present-day Cephalochordate genera represent a relatively recent offshoot of the ascidian stem. This would not in any important way depreciate their significance for the biologist. The modern higher chordates probably arose from ascidians much as *Amphioxus* did: that is all we are likely to know about the problem, and we are lucky to know so much.

P. B. Medawar

Department of Zoology,
University of Birmingham.
March 31.

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[9] Mr. H. K. Pusey, who has given me the most valuable criticism in the preparation of the paper, suggests that the dorsal mouth and anterior endostyle may also be 'forward looking' characters in just this sense. In Ascidians, as in *Amphioxus*, the mouth rudiment first appears in an antero-ventral position.
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Effect of Moonlight on Insect Activity

It has been known to entomologists for many years that if a bright light is used for attracting insects at night, the catches are considerably higher near the period of new moon than near full moon. One of us (C. B. W.) showed[1,2] that in three successive years, between May and October, the catches in a light trap, both of Lepidoptera alone and of all insects together (chiefly Diptera), reached a peak at, or shortly after, new moon, when the geometric mean catches were three to four times as great as those at full moon.

In spite of the fact that it is generally believed that other methods of catching are also poor at full moon, in the absence of any real evidence for this there was a distinct probability that the low catches in a light trap might be due to a lowered relative luminosity and hence a lowered attractiveness of the trap at full moon.

During the summer of 1950, we carried out continuous trapping of insects at night by means of a 'suction-trap' which draws in the insects by a strong electric fan, and thus is in no way dependent on reaction to light. The insects so caught are mostly Diptera; but many other orders are present.

An analysis of five complete lunar cycles between July and November 1950 shows that the geometric mean catches in the four weeks, that is, three days on either side of (1) full moon, (2) last quarter, (3) new moon and (4) first quarter, were as follows:

204; 589; 1,259 and 562.

Each of these figures is the mean of thirty-five nights.

These results are slightly affected by accidental differences in temperature and wind on the different nights, and when a correction is made for these, the figures become:

240; 490; 1,175 and 589.

Thus the geometric mean catch in the new moon week is nearly five times that in the full moon week. As the records include nights with cloud as well as clear nights, the effect of full moon on a clear night must be greater than this.

Mr. Healy, of the Statistical Department at this Station, informs me that the differences between full and new moon are significant at the 2 per cent level.

It appears, therefore, that the moonlight must have a definite effect on nocturnal insects, and that the low catches in a light trap at full moon are not merely due to a physical reduction of the efficiency of the trap.

Further repetition and analysis will be carried out during the present year. In the meantime, we would be glad of any other evidence on this problem, particularly long series of night catches of insects by any technique not depending on attraction to light.

C. B. Williams
B. P. Singh

Department of Entomology,
Rothamsted Experimental Station,
Harpenden.
Jan. 22.

[1] *Phil. Trans.*, *B*, **226**, 357 (1936).
[2] *Trans. Roy. Ent. Soc. London*, **90**, 272 (1940).

Photographic Prints produced by Red Blood Cells

Previously I have shown[1] that the red blood cells of certain animals, for example, guinea pigs, have a high sensitivity to light in contrast to others, for example, man, so that, with the same conditions of light intensity, 98 per cent of guinea pig erythrocytes and only 12 per cent of human erythrocytes are hæmolysed. The light which is responsible for this action is almost exclusively in the visible region.

I have since found this light sensitivity so distinct that it is possible to make photographic prints of any kind, such as a portrait with all its details, by this means.

The method used is as follows: a solution of 2 per cent agar in saline is mixed with a few drops of guinea pig blood, poured on to a glass plate and, after it becomes solid, covered with another glass plate. Then the plates are framed with paraffin wax; on top of them any pattern, such as a photographic negative, is fixed. The blood plate mounted in this way is immersed in a glass vessel, cooled by running tap water and exposed for 15 min. to a strong electric light (1,000 watts), which is collected in a parabolic mirror. After 24 hr. in darkness, the picture appears, becoming gradually more distinct; time is the only developer required. The process is finally arrested by putting the blood plate (after removing the cover-plate) into a solution of 10 per cent formalin in saline for a few hours. After rinsing with water, the plate is dried and can be kept for years.

In spite of the fact that the picture is produced by light, and its aspect, with the exception that it is

not reversed, is very similar to a photograph with silver salts, the action involved is, of course, quite different. First it must be emphasized that it is not due to the iron content of the hæmoglobin or to a bleaching process. Indeed, the hæmoglobin contributes very little or not at all to the process, so that a plate made of hæmoglobin and agar is completely ineffective. What, in fact, causes the phenomenon described is a destruction of the membrane and/or stroma of a varied number of red cells according to the amount of light they are exposed to, and diffusion of the hæmoglobin so liberated over the whole plate.

W. Meyerstein

Department of Physiology,
University of Birmingham.

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Sorption of Solid Insecticides by Dried Mud

In the course of experiments on the persistence of deposits from aqueous suspensions of different particle sizes of volatile insecticides, it has been found that the residual toxicity of particles of any one size is influenced considerably by the type of material to which they are applied.

Most striking results have been obtained on mud blocks made from 'murram', a lateritic ironstone, used in the construction of walls of houses in Uganda. Crystals of all insecticides used rapidly disappear from the surface of these blocks when they are kept at 78° F. (25° C.), and even those of DDT, which is usually regarded as a contact insecticide with a long residual life, are no longer visible after only a few days. As would be expected, the larger the particle the longer it persists; but for any given size-range the insecticides used can be arranged in order of increasing persistence, thus: 'Aldrin', gamma isomer of benzene hexachloride, 'Dieldrin' and DDT.

When DDT and 'Dieldrin' crystals are no longer visible on the surface, the mud blocks lose their toxicity to mosquitoes (*Aedes ægypti*, L.) exposed to them for long contact periods. On the other hand, blocks treated with the gamma isomer of benzene hexachloride or with 'Aldrin' continue to be effective for a considerable time, after the disappearance of the crystals, against mosquitoes resting on the surface.

Chemical tests have shown that with 10–20 micron particles of DDT and gamma-benzene hexachloride, almost the whole of the dosage applied can be recovered from the interior of the block. At a dosage of 25 mgm. of these particles per sq. ft., almost all the DDT is sorbed in the top tenth of an inch, suggesting that considerably higher dosages could be applied before the block becomes saturated. Dosages of 10–20 micron gamma-benzene hexachloride particles of the order of 200 mgm. per sq. ft. do, in fact, disappear from the surface in 24 hr. at 78° F. The rate of disappearance from the surface decreases as the relative humidity of the atmosphere increases. This may be explained by competition between water vapour and the insecticide vapour for the adsorbing surface. An interesting effect observed is that under absolutely dry conditions the sorbed DDT is catalytically decomposed to the ethylene derivative, the soil used having a high iron content. This again suggests that the insecticide is present in the block as a highly active surface layer.

The gamma isomer of benzene hexachloride and 'Aldrin' have, in contrast to DDT and 'Dieldrin', a marked fumigant action against *A. ægypti*, and there is ample evidence to show that the residual toxicity after the disappearance of crystals from the surface of blocks treated with these insecticides is due to the fumigant effect from the material inside the block. Desorption of the volatile insecticides takes several months for completion as compared with a few hours for the sorption process.

Crystals of gamma-benzene hexachloride persist for a much longer time on non-absorbent materials, such as glass and metal plates, than on mud blocks; but toxicity is completely lost as soon as the crystals disappear from the surface. Sorption of gamma-benzene hexachloride occurs on such materials as plaster fibreboard and unpainted wood, but to a much less extent than on mud blocks.

Commercial wettable powders and oil-bound suspensions of these insecticides behave in the same way as the pure materials on Uganda mud. Similar results are obtained with soil from Taveta in Kenya and with Oxford, Weald and Gault clays from Britain. It is intended to test other soils used in the construction of houses in other tropical countries as soon as the materials are available.

These results are of obvious practical importance in the control of adult mosquitoes in houses the walls of which are constructed of dried mud. The difference in effectiveness of DDT and benzene hexachloride wettable powders against *Anopheles gambiæ*, Giles, in houses with mud walls in Africa may be accounted for partly, at least, by the rapid sorption of both insecticides into the wall, resulting in one case in a complete loss of toxicity and in the other a persistent fumigant effect. Residual effects obtained with DDT wettable powders in houses of this type may be due only to the deposit on the roof. Variations in the persistence of insecticides on different types of material may help to explain the conflicting results reported in field-trials against malaria vectors in different parts of the world. Sorption of insecticides may be of significance in treatments against soil insects and in soil fumigation.

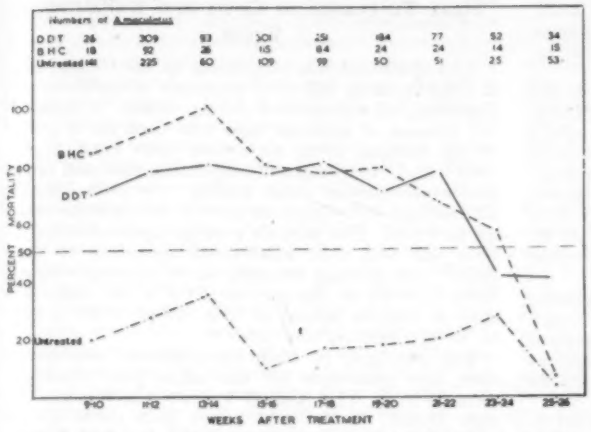
It is intended to publish a full report on these experiments.

A. B. Hadaway
F. Barlow

Colonial Insecticides Research Team,
c/o Ministry of Supply,
Chemical Defence Experimental Station,
Porton, Nr. Salisbury,
Wilts.

DDT and BHC as Residual Insecticides in Malaya

An earlier report[1] described the effects of the residual insecticides DDT and BHC ('Gammexane') on *Anopheles maculatus* and *Culex fatigans* entering experimental huts fitted with window traps, following the method employed by Thomson[2]. *A. maculatus* was killed by wettable powders of both DDT (200 mgm./sq. ft.) and BHC (40 mgm. gamma isomer/sq. ft.) for at least twelve weeks after application. DDT killed few *C. fatigans*, the majority being irritated and driven out of the hut without feeding; BHC had the same effect but also killed large numbers for several weeks. Owing to reduced numbers of mosquitoes entering the huts over the later weeks of the experiment, no information was obtained on how long these doses of DDT and BHC would continue to kill *A. maculatus*. For this reason the experi-



48-hr. mortality of *A. maculatus* entering treated and untreated experimental huts. DDT, 200 mgm./sq. ft.; BHC, 40 mgm. gamma isomer/sq. ft.

ment was repeated in 1950 using wettable powders at the same doses, the insecticides being applied in January so that the deposits would be ten to twenty weeks old during March, April and May, the period when a seasonal increase in numbers of *A. maculatus* occurs in Malaya.

In most respects the results confirmed the findings of the previous year. The 48-hr. mortality of *A. maculatus* trapped in DDT, BHC and untreated huts is shown in the accompanying diagram. Taking 50 per cent mortality as the lower limit of effectiveness, it will be seen that both insecticides maintained this standard for 22–24 weeks, that is, nearly six months.

The initial mortality of *A. maculatus* entering the BHC hut was much lower than in the previous year (8 per cent compared to 66 per cent during weeks 9–12) and the majority were found alive in the window trap. Many died in the following twenty-four hours, and a large proportion of those still alive after twenty-four hours died the next day, that is, *maculatus* continued to die up to 48 hr. after contact with BHC. A similar, though less marked, effect was noticed with DDT.

DDT again had practically no lethal effect on *C. fatigans*, but continued to drive them out of the hut and reduce the number biting during the twenty-six weeks of the experiment. BHC was effective (50 per cent mortality) for only five to seven weeks against this species, and, unlike the previous experiment in 1949, there was little reduction in the biting-rate and mosquitoes were not driven out of the hut.

Information on the effective duration of DDT and BHC against *A. maculatus* was required primarily as a guide for field experiments in Malay kampongs (rural communities), where these insecticides were being applied, as residual sprays in houses, to control malaria. Anophelines in general do not rest in houses by day in Malaya; but pyrethrum knock-down sprays in kampong houses not treated with DDT or BHC showed that *A. vagus* and to a lesser extent *A. aconitus* could be found regularly. Neither species is considered to be a vector in Malaya, and precipitin tests on blood from the specimens caught in this way showed that very few had fed on man. For six months after the application of DDT, catches of anophelines in houses remained very low. But in BHC-treated houses relatively large numbers of *A. vagus* and *aconitus* were obtained by knock-down sprays as early as one month after treatment. There were several possible explanations: (i) the anophelines might be resting on unsprayed surfaces such as the roof; (ii) anophelines might be resting on sprayed surfaces but would ultimately die from the effect of the insecticide; (iii) *A. vagus* and *aconitus* might be less susceptible to BHC than is *A. maculatus*, and the insecticide was ineffective against these species one month after application.

Direct observations in BHC-treated houses showed that many of the anophelines were resting on sprayed surfaces, and that the favourite resting-place both in sprayed and unsprayed houses was on the lower portion of the wall usually within 3 ft. of the floor. There were indications that fewer anophelines were present in sprayed houses during the afternoon than in the morning, and, as is shown in the accompanying table, a considerable mortality was recorded for *A. vagus* and *A. aconitus* caught by hand in houses sprayed with BHC eight to sixteen weeks earlier.

Thus, although anophelines were resting by day on sprayed surfaces, investigation did not suggest that the BHC deposit was ineffective. Further observations will be necessary to confirm that the 40 mgm. gamma BHC deposit remains effective for six months in kampong houses, but there seems little reason to doubt its effectiveness up to four months. One must conclude that the presence of anophelines in houses sprayed with BHC is not in itself proof that the insecticide is no longer potent, just as the absence of anophelines from houses sprayed with DDT or BHC[3] does not necessarily mean that they have all been killed by the insecticide.

R. H. WHARTON

Institute for Medical Research,
Kuala Lumpur, Malaya.
Dec. 28.

Mortality of blood-fed females of *A. vagus* and *A. aconitus* found resting in sprayed and unsprayed houses. BHC applied 8–16 weeks earlier at 40 mgm. gamma isomer per sq. ft.

Species	Houses sprayed with BHC			Unsprayed houses		
	Number	Per cent mortality after		Number	Per cent mortality after	
		24 hr.	48 hr.		24 hr.	48 hr.
A. vagus	143	62	89	196	20	48
A. aconitus	30	60	70	41	22	39

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Inheritance of Resistance to DDT in the Housefly, *Musca domestica* L.

THERE have been many speculations on the mode of inheritance of resistance to DDT in the housefly (*Musca domestica* L.), but little scientific evidence in support of one theory or another. In 1950, Bruce and Decker[1] reported that it was a multiple gene character and was carried by both male and female flies. Reciprocal crossing experiments between flies

of a non-resistant laboratory strain and a DDT-resistant strain resulted in the F_1, F_2 and F_{1s} generations having a resistance exactly intermediate between that of the parents.

My experiments on flies of Italian origin, on the other hand, give support to the theory that DDT-resistance is controlled by a single pair of allelomorphs. Crossing experiments with four pairs of flies (two reciprocal crosses) gave consistent results. The progeny of a cross was exposed to a DDT deposit of 10 mgm./sq. ft. in glass cylinders, and the time when 'knockdown' occurred in each individual fly noted; in this way the resistance of every individual in the sample was measured.

The F_1 generation of a cross between non-resistant and resistant flies had a resistance similar, although not identical, with that of a completely non-resistant strain. These hybrid flies were slightly more resistant than the non-resistant strain; but there was no fly comparable with the resistant parent.

A clear-cut segregation of non-resistant and DDT-resistant flies is apparent in the F_2 generation; the proportion of non-resistant individuals being approximately 75 per cent. The numbers of non-resistant and resistant flies in the F_2 generation of each of four crossing experiments is given in the accompanying table. Further support to this theory of single-factor inheritance was given by a backcross between a female fly of the F_1 generation and a resistant male, when the proportion of non-resistant to resistant flies in the offspring was approximately 1 : 1.

Cross	No. of non-resistant flies	No. of resistant flies	Per cent non-resistant flies	Deviation from expected 3 : 1 ratio / Standard error of expected ratio
Resistant male × non-resistant female	208	85	71	1·58
Resistant male × non-resistant female	211	83	72	1·18
Non-resistant male × resistant female	75	22	77	1·44
Non-resistant male × resistant female	275	93	74·7	0·13

Many workers[2–4] report a 'decline in the resistance' of DDT-resistant strains of houseflies when bred without coming into contact with DDT. Since non-resistance is dominant, the proportion of non-resistant flies in the population will increase over several successive generations provided the strain is not composed of resistant individuals only.

I wish to thank Prof. P. A. Buxton and Dr. J. R. Busvine for advice and encouragement, Dr. J. A. Fraser Roberts for helpful discussion and also the Medical Research Council for a grant supporting this work.

C. Mary Harrison

Entomology Department,
London School of Hygiene
and Tropical Medicine,
Keppel Street,
London, W.C.1.
Jan. 26.

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Heat Tolerance of Cows and Buffaloes in Egypt

An experiment was carried out on the College farm at Giza to study the heat tolerance of buffaloes and Egyptian, shorthorn and Jersey cows. A total of 107 females of different ages was used for a period of ten months, from November 1949 until August 1950. Body-temperature, respiration-rate and pulse-rate were recorded twice weekly. On each occasion six readings were taken at three-hour intervals starting at 6 a.m. The animals were grouped according to their age and then subdivided according to their breed. The average monthly air temperature ranged from 10·9° C. in January to 27·8° C. in July, and that of relative humidity from 49 per cent in May to 83 per cent in November.

The averages of body-temperature, respiration-rate, and pulse-rate for the adult pure shorthorn were 38·6° C., 17·2 and 31·9 times per 30 sec.; for pure Jersey, 38·2° C., 15·3 and 31·0 times per 30 sec.; for native cows, 38·2° C., 14·6 and 30·7 times per 30 sec.; and for buffaloes, 38·0° C., 12·2 and 28·0 times per 30 sec. respectively.

The averages of body temperature and respiration-rate were always higher for shorthorn cows than those of Jersey and native cows. The buffaloes had the lowest averages of body-temperature, respiration-rate and pulse-rate. For all the animals studied, body-temperature, respiration-rate and pulse-rate decreased as they grew older.

The increase in air temperature caused an increase in body-temperature and respiration-rate, and a decrease in pulse-rate. The increase in the relative humidity resulted in an increase in body-temperature and pulse-rate, while it did not seem to affect respiration-rate except in the case of the shorthorns, in which it caused an increase in respiration-rate also.

The help and encouragement of Dr. H. S. Soliman Bey, dean of the College, and Dr. A. F. E. Khishin, chairman of the Animal Breeding Department, are acknowledged.

A. L. Badreldin
Mohamed M. Oloufa
M. Abdel Ghany

College of Agriculture,
Fouad University,
Giza.
Jan. 11.

Infectious Pneumonia of Pigs

Pneumonia is more common in the pig than in any other domestic animal. Usually 20–60 per cent of pigs killed in slaughter-houses in the United Kingdom and Australia have some consolidation of the lungs. In the United States and also in Great Britain, much of the pneumonia in pigs has been thought to be due to the virus of swine influenza, a virus closely related to human influenza *A* virus. In addition to its economic importance, influenza in pigs is of interest owing to its connexion with disease in man: human strains can infect pigs naturally during epidemics in man[1,2], and it has been reported that pigs may harbour the virus of swine influenza for long periods[3,4]. Thus pigs might serve as reservoirs for influenza viruses infectious for man.

Using accepted methods of detecting a virus of the influenza group, we have tested pneumonic lungs

and sera from a considerable number of pigs in East Anglia, Ireland and Australia. Some specimens were from pigs which died during outbreaks of respiratory disease, thought by practising veterinarians to be swine influenza, whereas others were from pigs killed at slaughter-houses. In no instance was any evidence of an influenza virus obtained.

A type of pneumonia has, however, been transmitted in pigs by intranasal inoculation. Three different lots of inoculum which had been passed through a gradocol membrane, *A.P.D.* 0·8 μ, produced pneumonia, and on ten other occasions transmission was effected with material in which no bacteria could be detected. The disease so produced differed distinctly from swine influenza as described in the United States and as studied by one of us[5], in that the onset was slower, the course more protracted and prostration was much less than in swine influenza. After inoculation, the temperature may first rise and coughing be noticed at any time from the third to the eleventh day; but lesions of pneumonia on autopsy were not observed until more than one week after inoculation. The pneumonic lesions had a characteristic marginal distribution and were usually not extensive. The increase in body temperature was seldom great, and pigs that were afterwards shown at autopsy to have pneumonia usually showed only slight symptoms and continued to eat well. Intravenous inoculation of three pigs with infectious material was followed by a rise of temperature. The infectious agent survived storage at − 20° C. or in glycerol at 0° C. for at least fifty-five days. So far we have not succeeded in infecting chick embryos or laboratory animals, except possibly ferrets, in which an increase in temperature of doubtful significance was produced on three occasions.

We conclude that, at least during 1948–50, influenza has not been common in pigs in the areas studied in the United Kingdom, and that the prevalent form of pneumonia is caused by a filterable organism which is not a member of the influenza group of viruses. Although we have not progressed very far in our investigation of this disease, mainly owing to difficulties in reproducing it consistently, we feel that a useful advance has been made by recognizing this form of infectious pneumonia of pigs as quite distinct from swine influenza, with which it has been confused. Investigation of this disease, which is probably one of the most common diseases of pigs, continues in this laboratory. A detailed account of the research outlined above will be published shortly[6]. Not only did we fail to find evidence that pigs serve as a reservoir for human influenza, but also an investigation carried out by one of us strongly suggested that even the virus of swine influenza does not ordinarily persist for more than about a week after infection[5].

One of us (T. S. G.) is working with a grant from the Agricultural Research Council.

T. S. Gulrajani
W. I. B. Beveridge

Department of Animal Pathology,
University of Cambridge.
Jan. 20.

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Pore Canals in a Spider Cuticle

Pore canals have been described in the cuticles of many insects and Crustacea. In the Arachnida less is known of them; but channels containing cytoplasmic filaments have been demonstrated in ticks[1], and vertical striations in the 'exocuticula' of *Tegenaria atrica*[2] have been described and homologized with the pore canals of insects.

In a recent examination of the cuticle of *Tegenaria domestica* (L.) pore canals have been observed in sections of the cephalothorax. They extend from the outer edge of the inner endocuticle and pass through the tanned exocuticle to the amber layer of the epicuticle, which they do not appear to penetrate. In sections of paraffin-embedded material they appear as vertical striæ, the courses of which seem to be deflected in the outer portion of the exocuticle which appears more homogeneous and is more heavily tanned than the inner, laminated portion. All the courses are deflected in approximately the same direction. The significance of this is not clear. Striking information on the structure of the striæ was obtained from tangential sections of the ventral anterior cephalothoracic cuticle to which the chitosan test[3] had been applied. The whole of the exocuticle and the inner endocuticle became purple-red, indicating the presence of chitosan (and therefore in the untreated cuticle of chitin), and the pore canals assumed the same colour but much more intensely, and so stood out clearly from the rest of the cuticle. In these preparations they were not revealed as simple striæ as in the paraffin preparations, for each canal is produced into a number of branches distally, like those of some insects[4–6]. The central part of each canal is expanded and coiled in a loose spiral resembling the pore canals of two-day old third instar larvæ of *Sarcophaga*[4,7], of the cockroach[4] and of adult *Tenebrio*[5]. Proximally the canals become slender again and end at or near the junction of the exocuticle and inner endocuticle.

The fact that they contain chitosan-positive material indicates at once that the canal contents are cuticularized, at least in the later stages of the instar. In stained sections of the cephalothorax directly after the moult, the canals are not visible at all in the endocuticle, which stains with light green or aniline blue; but in sections of the older and partly tanned cuticle they stain with the acid fuchsin of Mallory triple and Masson trichrome stains, so that their courses are easily visible in the inner parts of the tanned exocuticle. In the outermost part of the tanned region they do not seem to stain but appear only as fine dark lines. In fully hardened and darkened cuticles the canals do not stain at all and appear as fine dark lines along the whole of their length. These staining reactions would suggest that in the early stages of the instar the canals have cytoplasmic contents or contain material similar in composition to that of the surrounding cuticle. Later they would appear to be impregnated with some substance of higher iso-electric point (as, in fact, occurs during the hardening and darkening of the exocuticle in which a similar sequence of staining reaction occurs) and finally to be sclerotized, so losing their ability to stain.

In being both chitinized and sclerotized these pore canals closely resemble those of the larva of *Diataraxia*[8]. The pore canals of the adult *Tenebrio*[5] are also sclerotized, but differ from those of *Tegenaria* in that they do not at any stage contain chitin,

whereas those of *Sarcophaga* larvæ[6,7] are chitinized but not sclerotized.

M. T. Sewell

Department of Zoology,
University,
Manchester 13.
Jan. 16.

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Excretion of Yttrium-91 in Rabbits

Estimation of the excretion of yttrium-90 by analysing the decay curves of excreta when a solution of strontium-89, together with strontium-90 and yttrium-90 in radioactive equilibrium, was injected into young and adult rabbits on different diets suggested that the excretion of yttrium was affected by age but not by diet[1]. The method of estimation was open to large errors.

Effect of Age on the Excretion and Retention of Yttrium-91

Age	Yttrium-91 retained per gm. of bone (per cent)	Yttrium-91 excreted (per cent)		Yttrium-91 retained in carcass other than bone (per cent)	Total recovery (per cent)
		Urine	Fæces		
5–7 weeks	0·60	10·1	6·3	6·7	84·8
,,	0·62	13·2	3·4	6·3	86·2
,,	0·66	12·6	2·9	5·3	87·3
7 months	0·39	19·6	2·9	9·3	89·9
,,	0·32	23·5	3·4	8·4	87·3
,,	0·27	29·0	3·0	8·4	89·3

The effect of age has been confirmed by actual estimations of both retention and excretion following injection of yttrium-91 (see table). The mean retention per gram of bone in three weanling rabbits five–six weeks old on a medium calcium diet killed nine days after an injection was 0·63 per cent per gm. of bone, while in three seven-months old rabbits it was 0·33 per cent of the injected dose per gm. of bone. The mean excretion in the urine in weanlings was 12·0 per cent of the injected dose, whereas in adults it was 24·0 per cent of the injected dose.

These findings confirm that the decay curve method for estimating the excretion of yttrium-90 has validity. They are also of interest since Copp *et al.*[2] state that the age of the animal does not affect the excretion and retention of yttrium in rats. There is at present no explanation for this apparent difference between the two species.

This work was carried out on behalf of the Protection Sub-Committee of the Medical Research Council's Committee on Medical and Biological Applications of Nuclear Physics.

Barbara Kidman
Margaret Tutt
Janet Vaughan

Department of Pharmacology,
Oxford.
Jan. 15.

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High Concentration of *nor*Adrenaline in Calves' Suprarenals

Extracts of the suprarenal medulla of many mammals, including man, contain both adrenaline and *nor*adrenaline, the latter being present to the extent of about 30 per cent of the total[1]. The proportion of *nor*adrenaline in extracts of tumours of the adrenal medulla is much higher[2]. It is possible that this difference may be related to the fact that the tumour cells are relatively undifferentiated and thus may be more comparable with embryonic tissue than with adult tissue. True embryonic tissue is difficult to obtain; but an opportunity arose recently of examining the suprarenal glands of male calves shortly after birth. I am grateful to Dr. R. S. Comline for supplying suprarenals from decerebrate calves. The whole suprarenal glands were removed at the end of the experiment and immediately extracted with 0·1 *N* hydrochloric acid in the usual way[3]. The extract was assayed against adrenaline on the rat's uterus and against both adrenaline and *nor*adrenaline either on the rat's colon or on the rabbit's intestine. A high proportion of *nor*adrenaline was found in every extract, as is shown in Table 1.

Table 1. Calves' Suprarenals

	No.	Age (days)	*l*-Adrenaline (mgm./gm.)	*l*-*nor*Adrenaline (mgm./gm.)	% *nor*Adrenaline
Experimental	1	1	1·6	2·6	62
	2	3	0·8	1·9	70
	3	4	2·2	5·4	71
	4	6	1·9	2·3	55
	5	6	1·3	3·9	75
	6	8	0·5	2·5	83
Slaughter-house	7	5	1·0	2·7	75
	8	>7	6	6·7	51
	9	>7	5	4·6	48
	10	>7	2·5	7·4	74
Mean					66

Since these results were different from those obtained by von Euler[4] with cattle suprarenals, three experiments were performed with whole bullocks' glands from the slaughterhouse. The glands were put into ice-cold 0·1 *N* hydrochloric acid about 30 min. after death and were taken to the laboratory, where the extracts were prepared and tested. The results, which are shown in Table 2, are in agreement with those of von Euler.

Table 2. Bullocks' Suprarenals

No.	*l*-Adrenaline (mgm./gm.)	*l*-*nor*Adrenaline (mgm./gm.)	% *nor*Adrenaline
1	0·94	0·22	16
2	1·25	0·7	36
3	1·75	1·2	41
Mean			31

The suprarenals of three calves were also collected from the slaughterhouse, and results from these are included in Table 1. Comparison of Tables 1 and 2 shows that the proportion of *nor*adrenaline is greater in calves than in bullocks ($P < 0·01$). The difference is due to a greater absolute amount of *nor*adrenaline in the calves' glands; the amount of adrenaline in experimental calves is not different from that in bullocks. Calves' suprarenals from the slaughterhouse, however, contain more adrenaline ($P < 0·01$) and even greater amounts of *nor*adrenaline. This may be due to the fact that the animals were older or that they were not used for experiment. It is

difficult to decide which suprarenals are in the more physiological condition.

The *nor*adrenaline used in these experiments was kindly given by Dr. H. Blaschko of the Department of Pharmacology, Oxford, and Dr. M. L. Tainter of Sterling Winthorp Research Institute.

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PAMELA HOLTON

Physiological Laboratory,
Cambridge.
Jan. 16.

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Zinc Content of the Genital Organs of the Rat

IN a recent review, Vallee and Altschule[1] have suggested that though many workers have estimated zinc in living tissues, the methods used have often been inaccurate. We have estimated the zinc content of certain tissues of the Collip hooded rat by the dithizone method of Vallee and Gibson[2]. Mature animals were used which were fed on a diet of fox chow containing about 75 μgm. zinc per gm., supplemented with carrot and cabbage. Most tissues contained about 15–30 μgm. zinc per gm.; but certain male genital organs showed wide deviations from this range. The literature contains few references to the zinc content of the genital system, though Bertrand and Vladesco[3] reported high results in herring's and horse's testis, pig's seminal vesicle, rat's epididymis and in the prostate of the bull and of man. Kadota[4] mentioned briefly that zinc could be detected by a relatively insensitive histochemical method in the rabbit prostate. The figures given by Leiner and Leiner[5] for rat's testis and by Eggleton[6] for human testis were within the usual range for soft mammalian tissues.

The accompanying table shows the results we have obtained with the genital organs of the rat, compared with a selected group of other tissues of the rat. The amount of zinc in the seminal vesicle contents was at the lower limit of accuracy of the method of estimation, and some of the zinc found may have been due to contamination by vesicular tissue juice. There is no doubt, however, that this material contained much less zinc than any other tissue examined. The posterior prostate, on the other hand, contained much more zinc than any other tissue except bone, and, when results were calculated as zinc per gm. ash, the posterior prostate was by far the richest source of zinc in the body. The epididymis also contained a considerable amount of zinc; but the female genital organs gave no striking results.

ZINC CONTENT OF ORGANS OF THE RAT

Organ	No. of samples	Zinc content of organ (mean with standard deviation) (μgm./gm. wet weight)	(mgm./gm. ash)
Seminal vesicle contents	3	2·15 ± 0·48	0·42 ± 0·09
Seminal vesicle tissue	5	22·1 ± 2·64	1·98 ± 0·30
Posterior prostate	11	180·0 ± 45·5	15·2 ± 3·62
Ventral prostate	9	13·7 ± 3·24	1·49 ± 0·43
Epididymis	8	46·2 ± 4·60	4·36 ± 0·50
Coagulating gland	6	25·0 ± 8·47	2·49 ± 0·81
Testis	7	28·9 ± 1·84	2·68 ± 0·23
Uterus	6	14·4 ± 3·23	1·47 ± 0·33
Ovaries	5	20·3 ± 1·49	1·51 ± 0·23
Brain	5	14·8 ± 1·32	1·06 ± 0·08
Liver	5	30·3 ± 1·57	2·23 ± 0·12
Lung	8	18·7 ± 1·61	1·59 ± 0·16
Submaxillary gland	5	16·5 ± 0·96	1·17 ± 0·06
Pancreas	6	23·3 ± 1·01	1·28 ± 0·16
Duodenum	5	23·9 ± 1·10	1·93 ± 0·28
Diaphragm	5	24·9 ± 2·51	2·17 ± 0·08
Tibia	5	233·0 ± 22·0	0·85 ± 0·05

It is noteworthy that the ventral prostate of the rat contained comparatively little zinc. The fact that the ventral and posterior prostates are very different tissues does not appear to be widely recognized, though they differ not only in gross and histological appearance but also in citric acid and fructose content[7] and in acid and alkaline phosphatase activity[8].

By the courtesy of Prof. Lyman Duff, of Montreal, and Prof. W. L. Robinson, of Toronto, we have been able to examine a number of specimens of human prostate taken at operation and at autopsy. The results, which will be reported elsewhere, were very variable; but most of the apparently normal glandular tissue contained more than 100 μgm. zinc per gm., and one value of 307 μgm. per gm. was observed. Four rabbit prostates contained 173, 233, 270 and 358 μgm. zinc per gm. It seems likely, therefore, that an exceptionally high zinc content is typical of the prostate gland.

C. A. MAWSON
M. I. FISCHER

Atomic Energy Project,
Chalk River,
Ontario.
Dec. 21.

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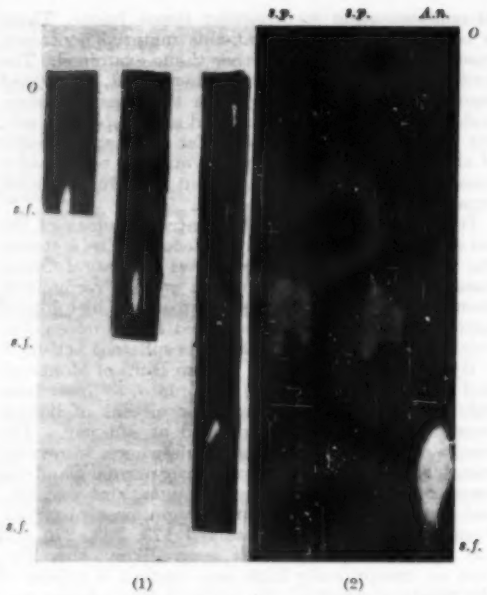
Detection of Enzymes by the Agar-Plate Method and its Application to Paper Chromatography

IN previous publications[1–4] from this laboratory, the use of the agar-plate method for the detection of enzymes has been described. This technique has now been adapted to the location of enzymes on paper. Preliminary investigations have shown that enzymes can be readily identified on the chromatogram by means of this technique.

The filter paper chromatographic experiments were carried out on paper strips (Whatman No. 1, 40 cm. × 12 cm.) by a procedure which resembles in general that developed by Consden, Gordon and Martin[5]. The paper carrying the enzyme near its upper end is hung from a glass trough containing aqueous alcohol or aqueous acetone (50 per cent) as solvent, the whole system being kept in a rectangular-sided glass jar saturated with the vapour of the solvent. After a suitable time of running (5–18 hr.), the paper is removed and the solvent front marked; the paper is allowed to dry at room temperature. The paper chromatogram is then placed on the surface of a thin layer of agar (2 per cent) containing the substrate. After a few hours (2–8 hr.)



(1) (2)

(1) Chromatogram of amylase from *Aspergillus niger* with varying distances of solvent front; *O*, starting point; *s.f.*, solvent front. (2) Chromatogram of β-amylase from sweet potato (*s.p.*) and amylase from *Aspergillus niger* (*A.n.*)

to allow the enzyme to hydrolyse the substrate, the agar layer is flooded with a suitable reagent which produces colours with the hydrolysed products. A number of substrates for various enzymes are available, which on hydrolysis yield products giving characteristic colour reactions with reagents. In the present investigation on the chromatography of amylases, starch (1 per cent) is used as substrate and iodine ($N/100$) as the reagent for detecting the hydrolysis of the substrate by the enzyme. For phosphatases, sodium phenolphthalein phosphate can be used as substrate and ammonia as the reagent; this produces a purple colour with the phenolphthalein liberated as a result of the hydrolysis of the substrate by the enzyme[4]. Similarly, urease, lipase, tyrosinase, proteoclastic and other enzymes can be detected on the agar plate.

The position of amylases on the paper is indicated by well-defined violet-coloured or clear spots against a blue background on the agar plate, depending on the nature and activity of the amylase (see accompanying photograph). The technique is of value because of its simplicity. The position of the enzyme on the filter paper can be distinctly seen on the agar plate, and the method is clearly capable of wide application to the study of paper chromatography of enzymes.

We have adapted this technique to the study of the behaviour of amylases on the chromatogram. The movement of amylases (β-amylase from sweet potato and amylase from *Aspergillus niger*) using aqueous alcohol (50 per cent) and aqueous acetone (50 per cent) as solvent systems has been studied. Preliminary investigations have shown that the movement of the enzyme on the paper depends on the nature of the solvent and the distance of the solvent front. The R_F values decrease with increase of the distance travelled by the solvent front. The R_F value of β-amylase from sweet potato is less than that of the amylase from *Aspergillus niger*. Clear and well-defined spots can be obtained when aqueous acetone is used as solvent. β-Amylase gives violet-coloured spots, whereas the amylase from *Aspergillus niger* gives colourless spots. High concentrations of the enzyme tend to produce a tailing effect. Typical R_F values of the enzymes are given in the accompanying table.

R_F values: aqueous acetone (50 per cent) as solvent

Exp. No.	Distance of the solvent front (cm.)	Amylase from *Aspergillus niger*	Amylase from sweet potato
1	10·1	0·87	
	20·3	0·80	
	35·9	0·77	
2	23·7	0·72	0·61
3	22·9	0·75	0·53

The extension of this technique to the separation of enzymes from one another is being studied.

K. V. Giri
A. L. N. Prasad

Department of Biochemistry,
Indian Institute of Science,
Bangalore-3.
Dec. 29.

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Production of Diphtheric Toxin of High Potency on a Cystin-free chemically defined Medium

It has been generally admitted that cystin or cystein plays an important part in the growth, especially in the toxin formation, of *Corynebacterium diphtheriæ*[1–6]. However, while studying the production of diphtheric toxin on the simplified chemically defined medium which was described in previous communications[7,8], complete replacement of cystin by thioglycollate has been observed without remarkable changes in the bacterial growth and toxin content.

Effect of Sodium Thioglycollate on the Growth and the Toxin Production of a Substrain of P. W. No. 8 Strain (Toronto Harvard) in a Cystin-free chemically defined Medium

Thioglycollate added (gm. per litre of medium)	Cystin added (gm. per litre of medium)	Final *p*H	Toxin content (*Lf* per ml. of medium)	Bacterial growth (mgm. *N* per 30 ml. of medium)
2·0	0·0	5·4	32	7·33
1·0	0·0	6·6	64	6·99
0·8	0·0	6·4	40	7·65
0·6	0·0	5·4	40	4·85
0·4	0·0	5·8	32	4·06
0·2	0·0	7·0	24	3·08
0·1	0·0	6·6	<4	1·26
0·05	0·0	7·0	0	0·71
0·0	0·0	6·4	no growth	no growth
0·0	0·4	5·4	40	6·05

Results showing the effect of thioglycollate in the cystin-free basal medium are given in the accompanying table. It will be seen that the addition of thioglycollate (more than 0·6 gm./l.) shows the same effect as that of cystin (0·4 gm./l.).

The basal medium used in this work was prepared by my method[7] with careful adjustment of starting

*p*H (7·0) and iron concentration (2 γ/30 ml.), and has the formula :

L-Asparagine	5·0 gm.
DL-Methionine	0·3 gm.
Potassium dihydrogen phosphate	5·0 gm.
Sodium chloride	4·0 gm.
Calcium chloride	1·0 gm.
Maltose	12·5 gm.
Sodium lactate	1·75 gm.
Mueller's II solution (ref. 9)	2·0 ml.
Distilled water	1,000 ml.

After inoculation with the pericle from a four-day culture of a substrain (adapted to the synthetic medium containing cystin) of Park Williams No. 8 (Toronto Harvard) strain, and the eight days incubation at 33–35° C., final *p*H, flocculation units and bacterial nitrogen content were measured.

It may be concluded that, as source of sulphur, thioglycollate can be utilized as well as cystin by the diphtheria bacillus, at least by the present strain. This is consistent with the suggestion from animal experiment[10].

Further research to find the actual mechanism involved is now in progress. This will be published in detail later.

MASAHIKO YONEDA

Department of Bacteriology,
Nagoya University Medical School,
Nagoya. Jan. 9.

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Relation of the Globular to the Fibrous Form of Silk Fibroin

WE have recently stated that if silk II (for example, silk of the cocoon filament[1]) is treated with hot alkali, there appears in X-ray diagrams at the equator one reflexion of 45 A., besides some additional higher orders (silk III[2]). Diagrams of higher-orientated samples show that the net plane with $D = 45$ A. coincides with the equator reflexions ($D = 9{\cdot}15$ and $4{\cdot}57$ A.), which, as is well known, represent the plane of the flat micelles. The 45-A. reflexion is much more intense and sharp than the equator reflexions of 9·15 and 4·57 A.

Further experiments showed that the following samples of silk could not be transformed into silk III : (1) cocoon filaments and films stored for one to two years ; (2) films of renatured silk[3,4] ; (3) films of silk II prepared from a gland which has been stored for some days. Silk samples mentioned under (1) give at the meridian diffuse layer-line reflexions of a 21-A. period in the first, second and third orders, which after alkali treatment became more intense. This effect is apparently the same as that observed by Kratky and Zahn[5] with cocoon filaments treated with nitric acid.

Samples mentioned under (1) and (2), even after having been stretched and rolled, show a considerably lower degree of 'higher orientation'. Their diffuse small-angle scattering is rather weaker than observed in recent preparations. However, the latter show a considerable decrease of small-angle scattering if transformed from silk II into silk III.

The ultra-violet absorption[6] shows that the alkali treatment, if carried out at 45° C. and within 60 sec., leads to 100 per cent phenolic dissociation of the tyrosyl groups, connected with a transformation of the keto form of some peptide groups into the enolic form. Measurements with linear polarized ultra-violet light show that the tyrosine residues absorb more intensely in the direction of the fibre axis (dichroic ratio 1·23–1·26), whereas the additional band of the C=N—
|
O
H
groups gives maximal absorption if the vector forms an angle of *c.* 40° with the fibre axis. The effects of phenolic dissociation and enolization are reversible, and reproducible also with older preparations.

Both the X-ray and the spectrographic effect are produced by means of the influence of the hot alkali ; but a direct connexion between them cannot be found at present.

Also cocoon filaments and untreated films show the intensive 'peptenol' absorption ; but films only do so within certain zones which between crossed nicols appear thoroughly homogeneous and have a lower birefringence than the rest of the film. On the other hand, the zones gave no characteristically changed X-ray diagram.

All the phenomena mentioned above point to the following interpretation. The stretching of the native gel consisting of globular units with a molecular weight of 33,000 (cf. Coleman and Howitt[8]) leads by means of a two-dimensional aggregation of these units to the formation of lamellæ of uniform thickness. The alkali treatment causes a separation of the surfaces. After short washing and drying of the alkali-treated samples, the lamellæ apparently remain separated one from another, causing a reflexion which corresponds with their thickness (including the probably very small space between them).

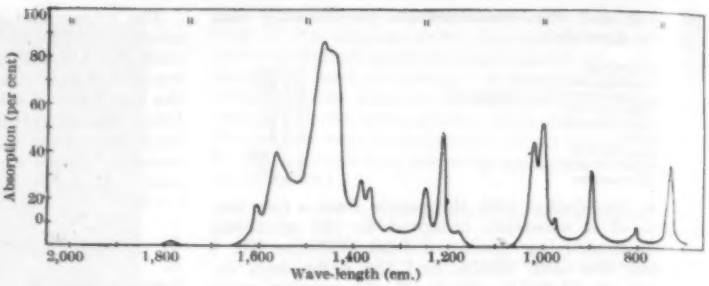
This interpretation explains both the striking sharpness and the high intensity of the 45-A. reflexions.

The reflexions at the equator corresponding to $D = 9{\cdot}15$ and $4{\cdot}57$ A. are not sharp. This cannot be due to small dimensions of the crystallites, for lamellæ with a thickness of 45 A. should give fairly sharp reflexions. An interpretation of the 45-A. reflexions as an intramicellar reflexion would presume lamellæ of considerable thickness, that is, extreme sharpness of the equator reflexions far from the centre. The fact that reflexions are diffuse points apparently to a deviation from the identity of the 'elementary cells' caused by certain variations from the 'pattern'.

Storage of the native silk gel without any loss of the bound water probably gives rise to a change of the globular molecules in such a way that lamellæ of uniform thickness can no longer be formed. Thus, the micelles lose more or less their ribbon-like shape and this makes understandable the deficient 'higher orientation'. The anisotropy of the small-angle scattering observed if the beam direction coincides with the direction of stretching indicates, however, that some lateral anisotropy of the lamellæ remains. Thus, direct evidence is provided for the ribbon-like shape which hitherto could only be identified by means of the appearance of the 'higher orientation'.

Storage of silk II also leads to an aggregation of lamellæ of equal thickness so that the hot alkali can no longer separate them. The reflexion at 21 A. resembling a layer-line might be interpreted simply

geometrically as indicating that the lamella consists of beaded strings running parallel with the fibre direction and shifted irregularly with regard to one another within this direction. On the assumption that the globular units have a dimension of 21 A. in the fibre axis—which seems reasonable in view of the molecular weight of 33,000 and the dimension of 45 A. in the side-chain direction—this interpretation could explain the diffuse layer-line reflexion.



We are still unable to say why both groups of new reflexions, those at the equator and those at the meridian, exclude one another. Furthermore, we wish to emphasize that the other interpretations offered are still somewhat hypothetical. Our investigations are being continued.

O. Kratky A. Sekora
E. Schauenstein I. Lapp
W. Berndt

Institute for Theoretical and Physical Chemistry,
University, Graz.
Dec. 23.

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Isolation of 2:3:5:6-Tetramethylpyridine from Coal Tar

During an investigation of the nitrogenous bases extracted by sulphuric acid from the 'benzol absorbing oil' fraction of coal tar, a solid base has been isolated which has been proved to be 2 : 3 : 5 : 6-tetramethylpyridine, a compound which has not hitherto been reported as a constituent of coal tar.

The solid separated out from a fraction (b. 130–132° C./100 mm.) obtained by high-efficiency fractional distillation (efficiency approximately 100 theoretical plates) of certain purified coal-tar base samples. After repeated crystallization of this solid from petroleum ether, a product was obtained which consisted of small white glistening platelets with a pleasant odour and a melting point of 76° C. From this pure product the picrate (m.p. 176° C.), the picrolonate (m.p. 259–260° C., decomp.) and the methiodide (m.p. 178° C.) were prepared.

The distillation-range and melting point of this base, as well as the melting points of the derivatives prepared, were found to be identical with those of a tertiary base of the formula $C_9H_{13}N$, which was isolated from the mixed pyridine bases in shale oil in these laboratories by Messrs. R. J. Benzie and J. N. Milne[1], and mixed melting points showed no lowering. Benzie and Milne suggested tentatively that this compound was 2 : 3 : 5 : 6-tetramethylpyridine on the basis of a comparison of its dissociation constant with those of other methylated pyridines, and this was further supported by analogy of the tetramethylpyridines to the tetramethylbenzenes.

There are few references in the literature to the preparation of this compound. Oparina[2], however, obtained a solid tertiary base in the reaction products on passing a mixture of formaldehyde, methyl ethyl ketone and ammonia over alumina in a heated copper tube. This solid base melted at 73–74° C. and its picrate melted at 173–174° C. This work has been repeated in this College by R. T. Smith, who obtained a solid product which on purification melted at 76° C., and the picrate of which melted at 176° C. The mode of preparation of this compound strongly indicates the 2 : 3 : 5 : 6 configuration. Mixed melting points of the base isolated from coal tar and its picrate with these products showed no lowering.

Oparina[3] has recently repeated his earlier work[2] and obtained a product which melted at 81° C. and the picrate of which melted at 173·5° C. On partial oxidation of this free base with permanganate, he obtained 2 : 6-dimethylpyridine-3 : 5-dicarboxylic acid, which on distillation with lime yielded 2 : 6-dimethylpyridine. Oxidation with excess permanganate yielded a crude tetracarboxylic acid which on heating lost carbon dioxide to give an acid melting at 308–309° C. From the mother liquors of the oxidation the 3 : 5-dicarboxylic acid and 2 : 5-dimethylpyridine-3 : 6-dicarboxylic acid were obtained.

This work proves quite conclusively that the product obtained by Oparina was 2 : 3 : 5 : 6-tetramethylpyridine, and, on the grounds that their reaction conditions were almost identical, it can be assumed that the product obtained by Smith was also 2 : 3 : 5 : 6-tetramethylpyridine, in spite of discrepancies in the melting points.

The infra-red absorption spectrograms for the three samples of solid base obtained in this College, which were prepared by Mr. J. L. Hales, of the Department of Scientific and Industrial Research, using saturated solutions in carbon tetrachloride/carbon disulphide mixture and a 50-μ cell, were found to be identical and to follow the graph reproduced herewith. The graph is corrected for solvent bands.

This evidence, together with the evidence of the mixed melting points, is sufficient to prove that these three samples are identical and thus that the solid base isolated from coal tar was 2 : 3 : 5 : 6-tetramethylpyridine.

A complete account of this work will be published at a later date.

H. B. Nisbet
A. M. Pryde

Chemistry Department, Heriot-Watt College,
Edinburgh. Jan. 4.

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Colour Reaction for Certain Mercaptoimidazoles

In a recent communication[1], I described a new colour reaction for the antithyroid drugs, 2-thiouracil and 4-methyl-2-thiouracil. This is based upon the yellow colour which is given when small concentrations of the drugs are treated with 2 : 6-dichloroquinone-chloroimide at *p*H 8·0. Although some free amino-acids, purines and other urinary solutes give coloured products in the reaction, these latter are insoluble in chloroform, whereas within certain concentration limits the coloured products of the reaction with the drugs are readily extractable from the aqueous phase by this solvent. By this means the colour reaction has been made specific, and has been applied to the colorimetric determination of methylthiouracil in urine.

Recently, Stanley and Astwood[2] and others have described the clinical use of antithyroid compounds of the mercaptoimidazole type, which have been shown to have a much higher *in vivo* activity than the thiouracils. In view of this we have been interested in the behaviour of certain mercaptoimidazoles in the above colour reaction, as a potential method for their determination.

Compounds of this type examined were 2-mercaptoimidazole, 4-methyl-2-mercaptoimidazole, and 4-amino-methyl-2-mercaptoimidazole (hydrochloride). These were dissolved in distilled water, and the *p*H of their solutions brought to 8·0 by the cautious addition of decinormal sodium hydroxide. After suitable dilution, aliquots of the solutions were taken and mixed with 2 ml. of a borate buffer, *p*H 8·0, and 0·1 ml. of a 0·4 per cent solution of 2 : 6-dichloroquinone-chloroimide in aldehyde-free absolute ethanol. Colour formation in each case was very rapid. Once the solutions had stood for 10 min. at room temperature, the solubility of the coloured complexes in chloroform was determined by shaking the solutions with 5 ml. of this solvent (see table). The amount of compound tested in each case was 0·5 mgm.

Compound	Colour reaction	Solubility in chloroform
2-Mercaptoimidazole	Rapid ; deep red	Soluble
4-Methyl-2-mercaptoimidazole	Rapid ; deep red	Soluble
4-Amino-methyl-2-mercaptoimidazole	Rapid ; orange	Soluble

The sensitivity of the colour reaction for each of the compounds tested was in the region of 10 μgm. Of the three compounds tested, the 2-mercaptoimidazole and the 4-methyl-2-mercaptoimidazole gave the best results as based upon the stability of their coloured products. The 4-amino-methyl-2-mercaptoimidazole gave an orange-coloured product which tended to decompose. Imidazole-4-5-dicarboxylic acid gave no colour in the reaction.

In spite of the preliminary nature of this work, it would appear that other compounds of the mercaptoimidazole type would behave analogously in the reaction, since the introduction of a methyl group at position 4 in the 2-mercaptoimidazole made no appreciable difference in the colour reaction. Since chloroform exhibits a selective solvent action in this instance, as it does in the case of the thiouracil reaction, it is believed that the colour reaction for the mercaptoimidazoles could be made the basis of a useful method for their determination. Whether this would be applicable to the determination of the compounds in urine is, of course, based upon whether these are excreted as such. A more detailed description of this work will be published elsewhere.

I am indebted to Dr. W. R. Trotter, of University College Hospital Medical School, London, for samples of the mercaptoimidazoles used; these were prepared by Dr. A. Lawson, of the Royal Free Hospital School of Medicine, to whom also thanks are due.

Ronald A. McAllister

Biochemical Laboratory,
Royal Samaritan Hospital,
Glasgow.
Jan. 11.

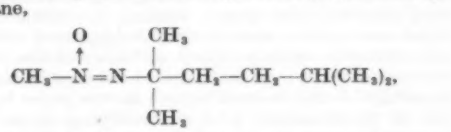
[1] McAllister, R. A., *Nature*, **166**, 789 (1950).
[2] Stanley, M. M., and Astwood, E. B., *Endocrin.*, **44**, 588 (1949).

Purely Aliphatic Azoxy Compounds with a Methyl Group attached to the Nitrogen Atom

Aliphatic azoxy compounds were first synthesized by one of us in 1931 [1,2], but all contained only tertiary alkyl groups attached to nitrogen.

In view of the work being carried out at Cambridge by Lythgoe and collaborators[3] on the natural product, macrozamin, which apparently contains an azoxy group with a methyl group directly attached, it seems worth while to make available our results on the synthesis of an azoxy compound containing such a group.

We have synthesized methyl-2-azoxy-2,5-dimethylhexane,



by the condensation of N-methylhydroxylamine with 2-nitroso-2,5-dimethylhexane by a method similar to that reported by one of us[4].

A suspension was made of 8·0 gm. (0·145 mole) of powdered potassium hydroxide in 100 ml. of dry ether, and to this was added with stirring over a 20-min. period 9·3 gm. (0·112 mole) of N-methylhydroxylamine hydrochloride. The ether was removed with an aspirator at 60 mm. pressure to leave a slightly yellow, curdy solid. To this was added at once 16·0 gm. (0·112 mole) of *bis*-2-nitroso-2,5-dimethylhexane. The mixture was heated to the melting point of the nitroso compound, whereupon a vigorous reaction ensued which required rapid cooling. When the reaction had subsided, the mixture was heated to 85° for 1 hr., and then to 110° for an additional 2 hr. After cooling, 40 ml. of water and 50 ml. of ether were added and the layers separated. The aqueous layer was extracted again with 25 ml. of ether. The combined ether extract was dried over sodium sulphate. After distilling the ether, the residue was distilled at 35 mm. pressure and gave the fractions shown in the accompanying table.

Fraction	Vapour temp. (° C.)	Weight of fraction	Colour of distillate
1	32°– 91°	0·3 gm.	Light blue
2	91°–103°	2·3 gm.	Very light blue
3	103°–105°	8·7 gm.	Light blue tint

Fraction 3 was analysed. Combustion analyses gave values of 62·4, 62·5 per cent carbon, and 11·4 per cent hydrogen; calculated values for methyl-2-azoxy-2,5-dimethylhexane are 62·8 per cent C, 11·6 per cent H. Molecular weights were 168, 170 for fraction 3 compared with a calculated 172. The yield of methyl-2-azoxy-2,5-dimethylhexane, considering fraction 2 to be mainly this compound, was 11·0 gm. (0·064 mole), 57 per cent. The refractive index was N_D^{20} 1·4330, and boiling point at 738·5 mm. was 184° with some decomposition.

Reduction with sodium in alcohol yielded the olefin 2,5-dimethyl-2-hexene as the only product isolated.

J. G. Aston
D. M. Jenkins

Department of Chemistry,
School of Chemistry and Physics,
Pennsylvania State College, Pa.
Dec. 9.

[1] Aston, Menard and Mayberry, *J. Amer. Chem. Soc.*, **54**, 1592 (1932).
[2] Aston and Parker, *J. Amer. Chem. Soc.*, **56**, 1387 (1934).
[3] Langley, Lythgoe and Riggs, [*Chem. and Indust.*, 75 (1951)].
[4] Aston and Allman, *J. Amer. Chem. Soc.*, **60**, 1930 (1938).

Improved Spraying Reagents for the Detection of Sugars on Paper Chromatograms

Phenolic spraying reagents for the detection of sugars on paper chromatograms as introduced by Forsyth[1], while greatly improving the selectivity of the method, had the disadvantages that the mineral acid attacked the paper, making it brittle when dried, and giving rise to dark background colours, and that the solvent caused diffusion of the sugar, with consequent poor definition of the spot boundary. Partridge[2] found reduced attack on the paper by the use of trichloracetic acid as acidifying agent, and reported improved spot definition with aniline hydrogen phthalate dissolved in butanol[3]. Other agents proposed have included aniline hydrogen oxalate[4], aniline – trichloracetic acid[5], benzidine – acetic acid[6], and ethanolic solutions of phenols and amines acidified with small amounts of hydrochloric acid[7].

Experiments carried out in this laboratory have shown that good definition with only moderate attack on the paper can be obtained by using butanol solutions of phenols (0·2 per cent), acidified immediately before use with an equal volume of 0·25 *N* hydrochloric acid in butanol. Tests carried out using phthalic and acetic acids as acidifying agents for phenols showed that these acids were too weak to be effective; but consideration of the relative strengths of acids indicated that phosphoric acid might prove suitable. This acid has been used by de Whalley[8] for the detection and estimation of raffinose. Chromatograms were prepared carrying rhamnose, xylose, arabinose, dextrose, galactose, mannose, lævulose, sorbose, sucrose, maltose, lactose and raffinose, using upward development in *n*-butanol : ethanol : water (4 : 1 : 5). These were sprayed with 0·2 per cent ethanolic solutions of resorcinol; naphthoresorcinol; orcinol; alpha-naphthol and phloroglucinol, each reagent being acidified with (i) an equal volume of 0·25 *N* hydrochloric acid, and (ii) 0·1 volume of orthophosphoric acid (1·85 sp. gr.).

In each case acidification with phosphoric acid increased the number of sugars detectable by the reagent. For example, naphthoresorcinol – hydrochloric acid showed only lævulose, sorbose, sucrose and raffinose, whereas phosphoric acid brought up all the twelve sugars mentioned. Partridge[2] noted that pentoses could be detected by naphthoresorcinol on heating the sprayed chromatogram in a moist atmosphere, and it was observed when using phosphoric acid that the papers always felt damp after heating; the enhanced effects found may be due to the hygroscopic nature of this acid. The spot definition was good with phosphoric acid in ethanol, but in general no improvement resulted from preparing the reagents in butanol. With alpha-naphthol, butanol reduced both the range of the reagent and the clarity of the spots.

A reagent prepared by mixing butanol solutions of 2 *N* aniline (1 volume) and 2 *N* phosphoric acid (2 volumes) showed an increased range over aniline hydrogen phthalate, all twelve sugars again being detectable.

J. L. Bryson
T. J. Mitchell

Department of Technical Chemistry,
Royal Technical College,
Glasgow.
Jan. 17.

[1] Forsyth, W. G. C., *Nature*, **161**, 239 (1946).
[2] Partridge, S. M., *Biochem. J.*, **42**, 238 (1948).
[3] Partridge, S. M., *Nature*, **164**, 443 (1949).
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[8] de Whalley, H. C. S., *Inter. Sugar J.*, **52**, 127, 151 (1950).

Inorganic Analysis by Paper Ionophoresis

Since the description of the electrophoresis of amino-acids by Wieland and Fischer[1] several workers[2,3] have made observations on the ionophoresis of inorganic ions inside filter paper. However, these studies were purely theoretical and did not indicate the possibility of separating inorganic ions for analytical purposes. Preliminary work in this laboratory[4] has shown that with the use of 1 *N* hydrochloric acid as electrolyte and 70 volts, a number of mixtures of metal ions can be separated into three fractions: anionic, cationic and isoelectric.

In this communication further experiments along these lines are described which indicate that separations analogous to those obtained by paper chromatography are possible by the use of ionophoretic techniques.

The technique employed was essentially that of Durrum[5]. A strip of paper 1 cm. × 20 cm. is hung over a T-shaped glass rod so as to hang with its ends in one limb of U-tubes filled with the electrolyte, and the whole is covered with an inverted gas jar. Carbon electrodes are placed in the other limb of the U-tubes and connected to a source of D.C. of 70–150 volts. The solution to be analysed is placed at the apex of the paper strip and the paper strip moistened carefully with electrolyte solution. Current is passed for two to three hours, the paper removed and held in hydrogen sulphide or other suitable reagent.

In the earlier communication[4], it was noticed that the copper group cations could be resolved into three bands, namely, copper–cadmium–lead, bis-

muth and mercury, by the use of 1 *N* hydrochloric acid. By trying various concentrations of the acid it was found, however, that when 0·5 *N* was employed a separation of all the metals occurs, and also that the order of separation is the same as for a paper chromatogram with butanol containing hydrochloric acid. A typical ionophorogram run with 120 V. for two hours gave the following bands: Cu^{2+} travelled towards the cathode, front 22 mm., rear 6 mm.; Cd^{2+} and Pb^{2+} form overlapping zones from −2 mm. to +6 mm.; Bi^{3+} travels towards the anode, front band 22 mm., rear 12 mm.; and Hg^{2+} travels faster towards the anode, front 31 mm., rear 25 mm. (All distances were measured from the apex.)

Formation of complexes such as thiocyanate complexes can also be employed for electrophoretic separation. Thus a mixture of cobalt and nickel can be separated already after one hour at 120 V. if a 7 per cent solution of potassium thiocyanate in 66 per cent ethyl alcohol is used as the electrolyte. A blue band of the cobalt thiocyanate complex moves rapidly towards the anode, while a colourless band of nickel moves slowly towards the cathode.

Analogous separation by paper chromatography was obtained by E. C. Martin[6] using butanol containing thiocyanic acid as solvent.

These two examples strongly suggest that, for every paper chromatographic separation of ions, equally efficient ionophoretic procedures are possible. Further work on this subject is in progress, and the relative merits of paper chromatography and ionophoresis will be investigated.

MICHAEL LEDERER

Science Department,
Newcastle Technical College,
Newcastle, N.S.W.
Jan. 25.

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Thermodynamic Equilibrium

IN previous communications[1,2] under this title, it was shown that the general chemical condition for equilibrium of a closed system can be obtained very simply by distinguishing between the internal and external work done by its forces.

For a complete discussion of thermodynamic equilibrium a rather more detailed analysis is necessary. The molar changes which may occur are in general of two kinds, namely, 'external' changes (dn_e), due to addition of material from outside, and 'internal' changes (dn_i), due to chemical reactions and movements within the system. The total change in the number of gram molecules is then given by $dn = dn_e + dn_i$ for each molecular species, and a closed system may be defined by $dn_e = 0$ for all constituents. An external change is restricted to those regions which are accessible from the surroundings across boundaries which define the extent of the system, and must be regarded as a transfer of material from outside across a boundary but no further, unless internally operating forces are absent. Also, there may be a force, X_b, in the surroundings but close to the boundary, which may do work, $X_b.dx_b$, when an external change takes place, and it is easy to show that the relation

$$\mu.dn_e = \mu'.dn_e + X_b.dx_b$$

must be satisfied whenever a constituent reversibly enters the system. Here μ' is the chemical potential of the constituent in the surroundings beyond the range of action of the boundary force. A boundary force must operate, however, before the entry occurs, since any motion after entry has occurred is an internal change and any work which accompanies it is done by internally operating forces, X_i. Hence it is not necessary to include the boundary forces in the energy equation given below. Thermodynamically, they do not belong to the system but to the surroundings, and their existence and value depend entirely on where we choose to place the boundary line.

It follows that all possibilities are allowed for when equation (1) of my first communication[1] is written in the form:

$$dE = T.dS + \Sigma\mu.dn_e + \Sigma\mu.dn_i - \Sigma X_i.dx_i - \Sigma X_e.dx_e.$$

In case the same force operates both internally and externally, it must, of course, appear twice in the above. Moreover, the law of conservation of energy requires that the purely internal changes must sum to zero. Hence, $\Sigma\mu.dn_i = \Sigma X_i.dx_i$ is always true. A system will generally comprise certain restraints in the form of barriers such as container walls, membranes, or partitions, all of which may be fixed or movable. These limit the possible composition changes and restrict the performance of work by the forces of the system but do not prevent the flow of heat. If, then, we exclude the possibility of perfect thermal insulation or of forces which oppose the flow of heat, we may describe thermodynamic equilibrium as a state of balance, subject to non-thermal restraints, which satisfies the following conditions of equilibrium: (1) *Condition for no thermal change.* The temperature of the system must be uniform throughout and equal to that of the surroundings. (2) *Condition for balance of forces.* Any external force capable of doing work on the system must be balanced by an externally operating force (X_e) of the system. This will apply both to the system as a whole and to any portion of it. (3) *Conditions for no chemical change.* As previously explained, for any possible virtual change, we must have, for the internal molar changes,

$$\Sigma\mu.dn_i = \Sigma X_i.dx_i;$$

and for each possible external change at a boundary between system and surroundings,

$$\mu.dn_e = \mu'.dn_e + X_b.dx_b.$$

In case the system is a closed one, these reduce to

$$\Sigma\mu.dn = \Sigma X_i.dx_i,$$

as previously given.

In this simple way, the chemical potential first introduced by Gibbs provides the key to all chemical aspects of the problem of thermodynamic equilibrium. It should be emphasized, however, that true thermodynamic equilibrium exists only when all the above conditions are simultaneously satisfied, and in particular the chemical conditions cannot be expected to hold unless the physical conditions are also satisfied. Further, any thermodynamical equation which is true only for reversible changes may also be regarded as a condition of equilibrium, and the conditions to which attention is directed here are simply those which directly describe the state of balance.

In certain electrochemical problems, for example, the illustrative example of the first communication[1], the consideration of individual barrier potential differences and of the chemical potentials of individual ions may be required. Since these cannot be measured, it is general practice to adopt conventional values. These are based upon the 'hydrogen scale', which takes the potential of the standard hydrogen electrode as zero, ignores metal–metal contact potentials, and attempts when necessary to eliminate liquid-junction potentials by means of salt bridges. So far as these conventional values are precise, they must be thermodynamically consistent, and in particular they must satisfy the conditions of equilibrium described above. The individual potential differences mentioned in my first communication[1] are to be understood as conventional values of this kind, since the metal–metal contact potential difference was not mentioned.

G. A. Elliott

Chemistry Department,
University of Western Australia,
Nedlands,
Western Australia.
Dec. 20.

[1] *Nature*, **165**, 934 (1950).
[2] *Nature*, [**166**, 962 (1950).]

Transient Creep in Pure Metals

When an annealed pure metal is loaded beyond the yield point, the deformation continues after the load is applied. The strain/time graph is called the creep curve. At constant stress Andrade[1] has shown it consists of the strain on loading, followed by decelerating or transient creep and finally steady-rate creep. Meissner, Polanyi and Schmid[2] have observed transient creep at the lowest temperatures; steady-rate creep occurs only at high temperatures.

Andrade[1,3] and others[4,5] have found the transient creep curve to fit

$$\varepsilon = \beta t^{1/3} + c_1. \qquad (1$$

But Phillips[6] and others[7,8] have used

$$\varepsilon = \alpha \log t + c_2. \qquad (2)$$

I have measured creep curves at constant stress using a new machine with pneumatic loading and continuous strain recording. The load could be applied rapidly and readings taken within a second of loading. A high sensitivity to strain (2×10^{-5}) combined with a large strain range (10 per cent) permitted measurements over a wide range of stresses and temperatures (− 196° C. to 170° C.). I have tested polycrystalline copper, aluminium and cadmium; and also aluminium with only a few grains per specimen.

I find for each metal that at low temperatures the creep curve is given by equation 2 and at higher temperatures by equation 1. In an intermediate range of temperature, which is lower for higher stress, the creep curve fits

$$\varepsilon = \alpha \log t + \beta t^{1/3} + c_3. \qquad (3)$$

The transition from equation 1 to equation 3 with copper is shown in Fig. 1. At the lower temperatures, the strain/log(time) curve is approximately linear. At higher temperatures it becomes concave upwards, especially at later times. If the α-component given by a tangent to the first part of the curve is subtracted from the total strain, the difference is linear with $(t)^{1/3}$, as shown in Fig. 2.

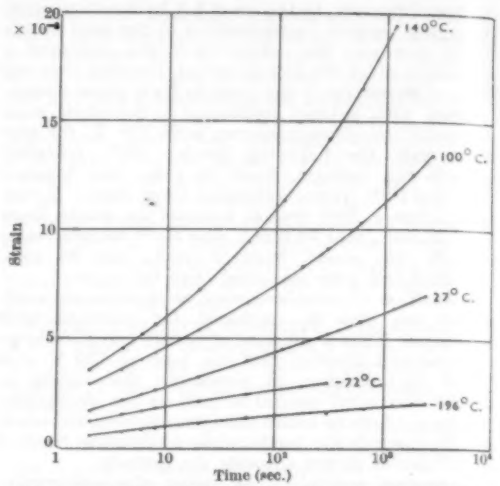

Fig. 1. Creep of copper at 18 kgm./mm.² at various temperatures. The total strain at 2 sec., from the top curve to the bottom, is: 116, 99, 86, 72 and 60

Theories have been given by Orowan[9] and Smith[10] which give equations 1 and 2 respectively. Orowan[9] and Los showed experimentally that pure metals do not obey a mechanical equation of state, that is $F(\sigma, \varepsilon, \dot{\varepsilon}, T) = 0$, and Orowan claimed his theory avoided one.

I have altered the stress by small amounts at various times during a creep curve and also changed the temperature between tests on one specimen at increasing stresses. I find that when α-flow alone is present, an equation of state is obeyed; but this fails when β-flow occurs.

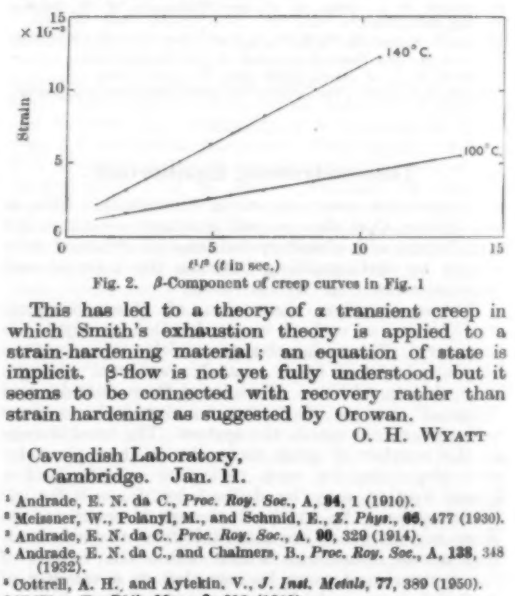

Fig. 2. β-Component of creep curves in Fig. 1

This has led to a theory of α transient creep in which Smith's exhaustion theory is applied to a strain-hardening material; an equation of state is implicit. β-flow is not yet fully understood, but it seems to be connected with recovery rather than strain hardening as suggested by Orowan.

O. H. Wyatt

Cavendish Laboratory,
Cambridge. Jan. 11.

[1] Andrade, E. N. da C., *Proc. Roy. Soc.*, A, **84**, 1 (1910).
[2] Meissner, W., Polanyi, M., and Schmid, E., *Z. Phys.*, **66**, 477 (1930).
[3] Andrade, E. N. da C., *Proc. Roy. Soc.*, A, **90**, 329 (1914).
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[8] Laurent, P., and Eudier, M., *Rev. de Metall.*, **47**, 39 (1950).
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[10] Smith, C. L., *Proc. Phys. Soc.*, **61**, 201 (1948).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 28

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. Eric Gordon and Mr. P. H. T. Beckett: "An Oxford Expedition to Persia".

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE (in the Lecture Room, Science Museum, Exhibition Road, London, S.W.7), at 5.30 p.m.—Dr. H. Hamshaw Thomas, F.R.S.: "Richard Bradley, a Neglected Plant Biologist of the Eighteenth Century"; Mr. A. J. Berry: "Some Aspects of the Early History of Electrochemistry".

Monday, May 28—Wednesday, May 30

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Conference on "Electrical Instrument Design".

Monday, May 28—Wednesday, June 6

THIRD WORLD PETROLEUM CONGRESS (at Scheveningen, The Hague).

Tuesday, May 29

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Prof. P. E. Vernon: "Recent Investigations of Intelligence and its Measurement".*

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, 26 Portland Place, London, W.1), at 6.30 p.m.—Annual General Meeting.

Tuesday, May 29—Friday, June 1

INSTITUTION OF GAS ENGINEERS (at the Institution of Civil Engineers, Great George Street, London, S.W.1).—88th Annual General Meeting.

Wednesday, May 30

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. H. Hotelling (North Carolina): "The Behaviour of Standard Statistical Procedures under Non-Standard Conditions".* (Further Lectures on June 1 and 4.)

CHEMICAL COUNCIL (at the Royal Institution, Albemarle Street, London, W.1), at 6 p.m.—Prof. J. W. Cook, F.R.S.: "Chemistry and the Conquest of Disease" (Chemistry in the Service of Man, 3).

Wednesday, May 30—Friday, June 1

IRON AND STEEL INSTITUTE (at 4 Grosvenor Gardens, London, S.W.1).—Annual General Meeting.

Thursday, May 31

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 4.45 p.m.—Dr. D. J. Bell: "Biological Syntheses concerning Carbohydrate Radicals".* (Further Lectures on June 7 and 14.)

Friday, June 1

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS, BIOLOGICAL METHODS GROUP (at the National Institute for Medical Research, The Ridgeway, Mill Hill, London, N.W.7), at 2 p.m.—Summer Meeting.

INSTITUTE OF ECONOMIC ENGINEERING (at Ward's Irish House, Princes Street, London, S.W.1), at 7 p.m.—Mr. Winston Rodgers: "Training Work Study Engineers".

Saturday, June 2

TELEVISION SOCIETY (at Norwood Technical College, Knight's Hill, London, S.E.27), at 10.15 a.m.—Summer Meeting.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

JUNIOR FELLOWSHIP IN APPLIED MATHEMATICS—The Registrar, The University, Bristol (June 1).

LAURA DE SALICETO STUDENTSHIP (part-time) for the advancement of cancer research—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 1).

LECTURER (Grade I) IN PHYSICS—The Clerk and Treasurer, Dundee Institute of Art and Technology, 40 Bell Street, Dundee (June 1).

ASSISTANT (Scientist, Grade II, with a first-class honours degree in science or the equivalent) TO THE DIVISIONAL CHIEF SCIENTIST—The Divisional Establishments Officer, National Coal Board, Northern (N. and C.) Division, First Floor, Ellison Buildings, Ellison Place, Newcastle-upon-Tyne (June 2).

CHIEF POLLUTION AND FISHERIES OFFICER (with executive ability and appropriate technical qualifications in chemistry, biology or sanitary engineering)—The Engineer and Acting Clerk, Glamorgan River Board, Old County Police Offices, 68a Cowbridge Road, Cardiff (June 2).

SENIOR PHYSICS AND MATHEMATICS MASTER at Victoria College, Cairo—The Secretary, Victoria College Council of Management, c/o Education Division, British Council, 65 Davies Street, London, W.1 (June 2).

ASSISTANT CURATOR at the Royal Botanic Gardens, Kew—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 193/51 (June 7).

SCIENTIFIC RESEARCH OFFICER IN THE GAS DYNAMICS SECTION of the Aeronautical Research Laboratories, Fishermen's Bend, Victoria, to assist in the operation of a high-speed (sub-sonic) wind tunnel, and to initiate and to carry out original research—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1 (June 7).

HISTOLOGIST IN THE PHYSIOLOGY DEPARTMENT—The Secretary, National Institute for Research in Dairying, Shinfield, Reading (June 9).

SENIOR PETROLEUM TECHNOLOGIST in the Bureau of Mineral Resources, Geology and Geophysics, Melbourne—The Senior Representative, Division of Industrial Development, Australia House, Strand, London, W.C.2 (June 9).

SENIOR RESEARCH STUDENTSHIPS IN ENGINEERING AND METALLURGY—The Registrar, University College, Singleton Park, Swansea (June 9).

ASSISTANT LECTURER IN THE DEPARTMENT OF MATHEMATICS—The Secretary, Bedford College for Women, Regent's Park, London, N.W.1 (June 15).

CHAIR OF GEOGRAPHY—The Secretary, The University, Aberdeen (June 15).

LECTURER IN MATHEMATICS at Auckland University College, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (June 15).

LECTURER or ASSISTANT LECTURER IN PSYCHOLOGY—The Secretary of University Court, The University, Glasgow (June 15).

CHAIR OF PHYSICS in the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 16).

LECTURER either in APPLIED MATHEMATICS or in APPLIED MATHEMATICS with special qualifications in FLUID MECHANICS, and ASSISTANT LECTURERS (temporary) IN PHYSICS and in CHEMISTRY (with special interests in INORGANIC CHEMISTRY)—The Registrar, University College, Singleton Park, Swansea (June 16).

SCIENTISTS, Grade III (with a good honours degree in chemistry, and experience in analytical technique desirable) at the Coal Survey Laboratories at Chester and Newcastle-upon-Tyne—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/335 (June 16).

SENIOR LECTURER or LECTURER IN (*a*) PHYSIOLOGY, and (*b*) ANATOMY, at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 16).

PROFESSOR OF MEDICINE at the Lady Hardinge Medical College for Women, New Delhi—The High Commission of India, General Department, India House, Aldwych, London, W.C.2, quoting 10/1/A (June 18).

RESEARCH PHYSICIST who will be concerned with investigations in semi-conducting materials and crystal valves—The Professor of Physics, The University, Reading (June 23).

ASSISTANT LECTURER (with special qualifications in organic chemistry) IN CHEMISTRY—The Registrar, The University, Reading (June 30).

PROFESSOR OF PHYSICS at the University of the Witwatersrand, Johannesburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (June 30).

SOREN RESEARCH FELLOWSHIP—The Assistant Secretary, Royal Society, Burlington House, Piccadilly, London, W.1 (June 30).

SENIOR RESEARCH FELLOW (Anthropologist) at the East African Institute of Social Research, Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 30).

SENIOR STUDENTSHIP (Permutit Co., Ltd.) IN CHEMISTRY, ENGINEERING or CHEMICAL ENGINEERING—The Master, St. Catharine's College, Cambridge (July 14).

SENIOR LECTURER IN BOTANY, and a LECTURER IN PHYSICS, at Rhodes University, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 31).

ASSISTANT DRILLING ENGINEER (with a degree in mechanical or mining engineering or equivalent institute qualifications with practical experience) in the Public Works Department (Geological Survey), Sudan—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Assistant Drilling Engineer, 4/161'.

ASSISTANT LECTURER IN PHARMACOLOGY (including Physiology)—The Registrar, The University, Nottingham.

ASSISTANT MECHANICAL ENGINEERS in the Sudan Irrigation Department—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Sudan Irrigation (Mechanical) 4/47'.

ASSISTANT METEOROLOGIST in the Gold Coast—The Director of Recruitment (Colonial Service), Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27118/50.

DEMONSTRATORS IN CHEMISTRY—The Registrar, The University, Nottingham.

DEPUTY DIRECTOR OF RESEARCH—The Director of Research, British Scientific Instrument Research Association, 20 Queen Anne Street, London, W.1.

GEOLOGIST (with high qualifications and practical experience in mining geology) by the Government of Iraq—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.27473.E.

GRADUATE ASSISTANT IN THE CHEMISTRY DEPARTMENT—The Principal, Municipal Technical College, Halifax.

LECTURER IN ENGINEERING MATHEMATICS in the Department of Engineering Production, an ASSISTANT (Grade A) FOR BIOLOGY, and an ASSISTANT (Grade B) to teach ENGLISH USAGE, mainly to technical students, at the Wolverhampton and Staffordshire Technical College—The Clerk to the Joint Education Committee, Education Offices, Wolverhampton.

PHYSICIST for research in Electronics Department, and a PHYSICIST with some knowledge of vacuum technique, for extended research programme on thermionic emission—The British Scientific Instrument Research Association, Sira, South Hill, Chislehurst, Kent.

Scientific Officers by the Division of Atomic Energy (Production) Research and Development Branch (Applied Research), Windscale Works, Sellafield, Cumberland, to undertake research work in the field of inorganic and radiochemistry on problems connected with atomic energy development—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting Ref. A.R.D.3/9.

Surveyor, and a Surveyor-Town Planner, in Aden—The Director of Recruitment (Colonial Service), 2 Sanctuary Buildings, Great Smith Street, London, S.W.1.

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ZOOLOGICAL NOMENCLATURE: NOTICE is hereby given that, as from November 4, 1951, the International Commission on Zoological Nomenclature will start to vote on the undermentioned applications involving the possible use of its plenary powers, published in Parts 5 and 6/8 of volume 2 of the *Bulletin of Zoological Nomenclature* (on May 4, 1951). Part 5. Applications relating to the following names involved in the Meigen (1800) problem: *Titania* versus *Chlorops*; *Dorilas* versus *Pipunculus*; *Tendipes* versus *Chironomus*; *Phlia* versus *Dilophus*; *Tylos* versus *Micropeza*. Part 6/8 contains 19 applications relating to ammonite names submitted in connection with the preparation of the international *Treatise on Invertebrate Paleontology*. These are concerned with (1) the validation of *Sphaeroceras* Bayle, 1878; (2) the suppression of *Planites* de Haan, 1825; *Planulites* and *Orbulites*, both, Lamarck, 1801; *Pelagus* and *Ellipsolithes*, both Montfort, 1808; *Globites* de Haan, 1825; *Ammonites* Bruguière, 1789; *Toxosphinctes* Buckman, 1923; (3) the determination of the species to which the names *Ammonites macrocephalus* Schlotheim, 1813, and *Ammonites angulatus* Schlotheim, 1820, are to be applied; (4) the suppression of the name *Ammonites cymodoce* d'Orbigny, 1850; (5) the designation of type species for the genera *Procerites* Siemiradzki, 1898; *Macrocephalites* Zittel, 1884; *Pictonia* Bayle, 1878 and *Rasenia* Salfeld, 1913; *Aulacostephanus* Tornquist 1896; *Kosmoceras*, *Harpoceras* and *Periphinctes* (all of Waagen, 1869); *Armioceras* and *Liparoceras*, both of Hyatt, 1867; *Normannites* Munier-Chalmas, 1892. The same Triple Part contains also applications for the use of the plenary powers to validate the names *Pecten asper* Lamarck, 1819, and *Gryphaea virgula* Deshayes, 1831, for the Pelecypod species concerned and a notice regarding the possible use of those powers to validate the name *Gryphaea* (Class Pelecypoda) as from Lamarck, 1819, in place of Lamarck, 1801.—Interested specialists are invited to send comments on the foregoing applications, for consideration by the International Commission on Zoological Nomenclature, to the Secretary to the Commission (address: 28 Park Village East, Regent's Park, London, N.W.1), as soon as possible and in any case prior to November 4, 1951, the close of the prescribed period of notice.

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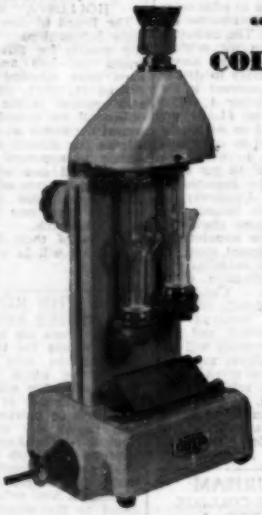

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